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Volume III
Regional Crop Production Trends

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16. ABSTRACT

This study identified and assessed, on a regional basis, the current and emerging trends in the U.S. crop production subsector that will have the most significant environmental implications. Panels of agricultural specialists evaluated and rated the most significant environmentally related trends. A primary conclusion of the study was that the crop production sector can, with achievable developments, realize projected 2010 moderate growth scenario production levels while concurrently realizing enhanced environmental effects relative to current (1977) conditions. To do so, the crop production sector must employ improved crop production inputs and more sophisticated management practices and residual controls. These conditions are, in turn, dependent upon (1) improved policies to control agriculture's exogenous factors and (2) requisite research developments to assure those improved crop production inputs, management practices, and residual controls. If these requisite research developments and improved policies are not forthcoming and implemented, then adverse and potentially serious environmental consequences can be expected to occur from the crop production system's residual outputs (pollutants) by 2010.

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ENVIRONMENTAL IMPLICATIONS OF TRENDS IN AGRICULTURE AND SILVICULTURE

VOLUME III:
REGIONAL CROP PRODUCTION TRENDS

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FOREWORD

Environmental protection efforts are increasingly directed towards preventing adverse health and ecological effects associated with specific compounds of natural or human origin. As part of this Laboratory's research on the occurrence, movement, transformation, impact, and control of environmental contaminants, management or engineering tools are developed for assessing and controlling adverse environmental effects of non-irrigated agriculture and of silviculture.

Agricultural and silvicultural practices, already significant sources of water and air pollution, represent areas of increasing environmental concern as these production systems expand to meet growing population needs. This study assesses the environmental implications and effects of short- and long-term trends in American agriculture and silviculture and identifies research needs and policy issues. The developed information should benefit environmental managers as they attempt to anticipate pollution problems of the future.

David W. Duttweiler
Director
Environmental Research Laboratory
Athens, Georgia

PREFACE

This report, "Environmental Implications of Trends in Agriculture and Silviculture, Volume III: Regional Crop Production Trends," is the third and concluding study report for the Environmental Protection Agency prepared by Development Planning and Research Associates, Inc., under the general title: "Assessment of the Environmental Implications of Trends in Agriculture and Silviculture, 1976-2010" (EPA Contract No. 68-03-2451).

The two preceding reports provide additional background and the supporting rationale for this study, which assesses the major subsector nonpoint source of pollutants within both the agriculture and silviculture sectors of the U.S. economy. These two preceding reports are titled "Environmental Implications of Trends in Agriculture and Silviculture--'Volume I: Trend Identification and Evaluation,' and ' Volume II: Environmental Effects of Trends.'"

By focusing on the crop production subsector of agriculture, the present volume's research study more specifically and intensively evaluates the subsector's trends and their associated individual and collective environmental effects on a regional as well as a national basis. Although the national implications of the crop production subsector's environmental effects are broadly applicable toward improved environmental management, the development of regional trends data and their environmental effects has especially significant consequences to an understanding of the crop production system, i.e., the recognition and delineation of important environmental effect variations among the regional subsectors.

ABSTRACT

This study identified and assessed, on a regional basis, the current and emerging trends in the U.S. crop production subsector that will have the most significant environmental implications. Beneficial and adverse environmental implications were assessed under both moderate and high growth scenarios for the long term (2010). The study also identified the major pollutants and their primary media--water, soil, and air--effects.

In a workshop setting, panels comprised of agricultural specialists representing five crop production regions--Northeastern, Southeastern, Cornbelt/Lake States, Great Plains and Western--evaluated and rated the most significant environmentally related trends. The important future and regional environmental-effect differences were identified. The study further identified the crop production subsector's exogenous factors, policy concerns and research needs that have environmental implications. The assessment of these factors indicated their important causal interrelationships.

A primary conclusion of the study was that the crop production sector can, with achievable developments, realize projected 2010 moderate growth scenario production levels while concurrently realizing enhanced environmental effects relative to current (1977) conditions. To do so, the crop production sector must employ improved crop production inputs and more sophisticated management practices and residual controls. These conditions are, in turn, dependent upon (1) improved policies to control agriculture's exogenous factors and (2) requisite research developments to assure those improved crop production inputs, management practices, and residual controls. If these requisite research developments and improved policies are not forthcoming and implemented, then adverse and potentially serious environmental consequences can be expected to occur from the crop production system's residual outputs (pollutants) by 2010. (Also the adverse environmental impacts would be expected to be greater under the high growth output levels than under the moderate growth output levels.)

Under the production requirements of the study's 2010 high growth scenario, the sector's projected environmental effects would be less advantageous. Still, though, with the exceptions of increased nutrient and pesticide levels in the Cornbelt/Lake States region and higher salt levels in the Western region, the high growth 2010 scenario's environmental effects would be more beneficial than those of present conditions.

This report was submitted in fulfillment of EPA Contract No. 68-03-2451 by Development Planning and Research Associates, Inc., Manhattan, Kansas, under the sponsorship of the U.S. Environmental Protection Agency. Work was completed as of November, 1978.

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Particularly instrumental in this study's research approach were the contributions of the evaluation workshop's regional panel members. These agricultural specialists assessed their own region's crop production trends; environmental implications of these trends; and those major exogenous factors, policy concerns and research needs that will affect the future growth-environmental effects potentials of the crop production system. These workshop participants are named below, and, further, their professional affiliations and areas of specialization are shown in Section II. DPRA sincerely adknowledges their contributions.

Region I: Northeastern

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- W. H. Allaway
- William K. Griffith
- Raymond J. Shipp
- Duane C. Wolf

Region II: Southeastern

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- Ralph A. Leonard
- David C. Martens
- Porter L. Russ

Region III: Cornbelt/Lake States

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- Marshal D. McGlamery
- Terry J. Logan
- David L. Mick
- Leo M. Walsh

Region IV: Great Plains

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- William F. Powers
- Theodore G. Sherbeck
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Region V: Western

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- Claude L. Fly
- Robert M. Hoffman
- Gerald L. Horner
- T. C. Tucker

Within DPRA many professional staff members and consultants contributed to the conduct of the workshop and in the preparation of this report. Those who provided major support include Raymond E. Seltzer, Geneva S. Hammaker, Gary A. Davis, S. MacCallum King, Richard L. Vanderlip, Vincent E. Gillespie, Frances A. Moyer, Linda D. Chapman, Daniel W. Francke, Barbara L. Lane and John P. Wagner.

Samuel G. Unger
Principal Investigator

EXECUTIVE SUMMARY

This study for the U.S. Environmental Protection Agency determined and assessed those current and prospective trends in five U.S. crop production regions that will most affect the regions' primary environmental media--water, soil and air. Both beneficial and adverse environmental implications were projected by the study's panels of agricultural specialists who represented each of the five major crop production regions--Northeastern, Southeastern, Cornbelt/Lake States, Great Plains, and Western.

This report contains, foremost, region-specific assessments of selected major trends, i.e., trends in crop production input use, management practices, and residual controls, and their expected environmental effects. Additionally, the report includes an identification and assessment of those exogenous factors, policy concerns, and research needs that importantly affect the crop production subsectors' environmental implications.

A. Conclusions

This study's primary conclusions, reached by the regional panelists, were that--with the use of achievable developments and improvements in inputs, management practices and residual controls, the crop production system can meet projected moderate-level output goals in 2010 and effect beneficial environmental impacts. If high growth output levels are realized, then, compared to moderate growth conditions, the projected environmental improvements will be reduced. Implicit in these conclusions was the assumption that requisite research developments and improved policies which allow at least limited control of the crop production system's trends and exogenous factors would be forthcoming. If these requisite research developments and improved policies are not forthcoming and implemented, then adverse and potentially serious environmental consequences can be expected to occur from the crop production system's residual outputs (pollutants) by 2010. The adverse environmental impacts would be expected to be greater under the high growth output levels than under the moderate growth output levels.

The study's indicated trends in input use, management practices, and residual controls that directly affect the environment may be influenced effectively through achievable research developments and more responsive crop production management policies. Also, an analysis of the exogenous factors, policy concerns, and research needs identified by the regional panels indicated that critical interrelationships exist among these factors. These relationships, shown in Exhibit I-1, indicate that more integrative policy and research coordination is needed to alleviate the disruptive influence of the cited exogenous factors.

B. Introduction

The crop production subsector is the major nonpoint source of pollution within agriculture. Its principal pollutants are sediment, nutrients, pesticides, and salt. All the primary environmental media--water, soil, and air--are affected by these pollutants.

This study identified and assessed the current (to 1977) and potential (to 2010) trends in the U.S. crop production subsector that are predicted to have the greatest environmental implications. The principal objectives of the study were:

(1) to identify and assess the major crop production subsector regional trends in input use, management practices,and residual controls, and their environmental implications in 1985 and 2010;

(2) to identify and assess each region's major pollutants and their primary media--water, soil, and air--effects;

(3) to identify, on a regional basis, those exogenous factors that may affect some trend and, thus, have major indirect environmental implications, and

(4) to identify each region's research needs and policy concerns that are germane to the crop production subsector's environmental implications.

The primary analyses in this study were made by panels of regionally-oriented specialists in a workshop setting. Using a background summary of regional/national data, following stated analytical procedures, and employing designed evaluation forms, the panelists assessed and modified, where necesary, the original list of trends contained in an interim report of this study. The panels' assessments included both an evaluation of individual agricultural trends and their aggregate environmental implications.

The workshop and other related assessments of the crop production subsector's trends were compiled on a regional basis in order to reflect the diversity of regional climatic, topographic, soil, and other natural conditions within the U.S. which determine regional crop selection and agricultural trends. The five regions designated in the study are depicted in Exhibit II-2.

C. Crop Production System

The crop production system--comprising inputs, management practices and outputs--was initially viewed as a closed system in each of the study's five regions. All components of the system were assessed, though the focus of analysis was on the environmental effects of the system's production residual-output.

External events (including exogenous factors, government policies, and research developments) 1/, though not directly controllable by the crop production system, were also identified and discussed by the regions' workshop panels. Factors such as groundwater depletion, legislative intervention, and rates of technological advancement were evaluated. In many cases these external events are so influential that individual analyses of their environmental implications, beyond the scope of this study, are warranted.

The crop production system's environmental effects were shown to be highly dependent on the interrelationships of its major components. These potential interrelationships are characterized in the generalized function as follows:

$$O(C,R) = F(I_1, I_2, \ldots MP_1, MP_2, \ldots RT_1, RT_2, \ldots \mid \text{EXTERNAL FACTORS})$$

where

O = Output
C = Crops
R = Residuals

I_i = Inputs, $i=1,2\ldots$
MP_j = Management Practices, $j=1,2,\ldots$
RT_k = Residual Treatments, $k=1,2,\ldots$

The preferred combination of inputs, management practices, and residual treatments that will provide for acceptable levels of both crop and residual outputs vary importantly on a regional basis as a result of climatic, topographic, soil and other natural characteristics. (Moreover, even site-specific variations in these component-combinations are usually appropriate.) Regional differences in natural characteristics that affect the crop production system are depicted in Exhibits III-3 to III-7.

D. Growth Scenarios: Present to 2010

Annual U.S. crop production is expected to increase substantially by 2010 to meet projected demands. Existing models were used to project this growth potential under two sets of conditions by using alternative, specified

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1/ When viewed more broadly, government policies and research developments are also subsets of exogenous factors. However, this study seeks to distinguish among these external events as a basis for improved environmental management in the crop production system.

values for variables such as gross national product, population, technological developments, and international trade. The USDA-Economic Research Service's (now the Economics, Statistics, and Cooperative Service) and the Water Resources Council's OBERS projections were utilized as the primary data sources.

This study required the development of specified growth scenarios, i.e., moderate and high growth levels, within which the trends and environmental implications of the regional crop production subsectors could be evaluated. For example, the national index-levels of crop production were projected to increase to 122 in 1985 and to 171 in 2010 (1972-74 = 100) under the moderate growth scenario, and to 143 in 1985 and to 196 in 2010 under the high growth scenario.

Regional crop production growth indices were also constructed for this study, and, in aggregate, they equaled the above national-level projections. These regional output growth indices are summarized in Exhibit IV-2. No study constraints were imposed on the panels regarding the expected levels of inputs needed or available. Where necessary, the panels assessed what they considered to be germane regional constraints (e.g. cropland availability) and the levels of inputs such constraints correspondingly required in order for the crop production sector to meet the specified growth conditions. The panels then assessed the environmental effects of such input levels.

E. Environmental Concerns: Current and Projected

The regional panels assessed the potential pollutants' effects on water, soil and air under three levels of inputs, management practices, and outputs: the current period (1977) level, the moderate growth scenario level in 2010, and the high growth scenario level in 2010.

The panels' evaluation of the relative rankings for each region required a three-step procedure. Initially, the panelists ranked the environmental concerns for the three media under current and future growth assumptions. Next, the relative effects of the pollutants among the three media were determined. Finally, the panelists assessed the relative extent to which each medium--water, soil, and air--was environmentally affected by the crop production subsector.

The results of the first two steps highlight important regional differences in specific pollutant problems within each environmental medium, and their ranking among media as explained in Section V. In summary, however, the aggregate environmental effects, as were determined in step 3, are illustrtive of varied regional environmental concerns. In this step each primary medium was ranked and rated on a scale of 1-100 where 100 was assigned to the principal environmental medium affected by the region's crop production system. These regional ratings were made for the current period and for the 2010 period--under both moderate and high growth conditions.

Under current conditions, the crop production system's effects on the water medium were rated first (index = 100) in four regions--Northeastern, Southeastern, Cornbelt/Lake States, and Western. The crop production effects on the soil medium were rated first in the Great Plains region. Under moderate growth conditions in 2010, only one medium ranking changed, i.e., the Northeastern region rated the soil medium first (100) whereas water medium concerns were rated second (90). Under high growth conditions to 2010, the Southeastern panel also increased its rating of the region's soil medium concerns (100)--equal to its water medium concerns. The air medium was judged to be of relatively minor concern for all five regions in each of three cases.

F. Crop Production Trends' Assessment: Nation and Regions

Current and prospective regional crop production trends associated with both the moderate and high growth scenarios were determined and evaluated by each of the study's panels. The workshop participants' environmentally related judgments were shaped, in part, by two principal factors: the growth potential in each region and the time-span within which the specified output goals were to be achieved. Moderate growth goals to 2010 were generally deemed achievable with expected environmental improvements in the primary media. However, production increases ranging from 13 to 17 percent higher under the high growth scenario in the same time-span would result in additional land utilization and a reduced use of environmentally favorable management practices. Consequently, increasingly adverse environmental effects from the crop production system would be expected under the high growth compared to those of the moderate growth scenario.

Specific crop production trends were determined and categorized as either input trends, management practice trends, or output (residual treatment) trends. The analysis included both individual-trend and composite-trends environmental assessments. For example, in the Southeastern, Cornbelt/Lake States, and Great Plains regions, the trend of increased land use, as an individual trend, was expected to induce adverse environmental effects, e.g., increased sediment loss; however, accompanying improvements in management practice trends are also expected in these regions--resulting in a composite beneficial sediment reduction under moderate growth conditions.

From the detailed and composite analyses shown in this report, the following aggregate summary results were forwarded by the regional panels. The Northeastern and Southeastern crop production regions are projected to achieve slightly improved sediment, nutrient, and pesticide environmental effects by 2010 under both growth scenarios. The Cornbelt/Lake States can expect major reductions in sediment loss under moderate growth, but this pollutant effect plus nutrient and pesticide losses would be adversely increased under high growth assumptions. The Great Plains region is projected to have beneficial changes in the crop production subsector's sediment, nutrient and pesticide environmental effects in 2010 compared to current effects under moderate growth, but relatively more adverse pesticide effects would probably occur under high growth. The Western region is expected to improve its crop production subsector sediment, nutrient and pesticide environmental effects under moderate growth, but salt accumulation in the soil and salt gains in water would increase under the high growth scenario. The requisite trends' assessments leading to these expected environmental implications are presented in Section VI.

G. Exogenous Factors

The preceding assessments focused on factors (and trends) that were internal to the crop production system; however, the system is also regularly affected by external events which may indirectly affect the crop production system's environmental impact. Implicitly, some external factors may also be favorably controlled in the future and, indeed, such control is projected for certain ones.

Three main types of external events were evaluated by the workshop participants: exogenous factors, government policies, and research developments. Specific events within each category were delineated and discussed by the regional panels and by the workshop collectively. These findings are reported in detail in Section VII - Exogenous Factors, Section VIII - Policy Concerns, and Section IX - Research Needs. In each case, the events described are those that are expected to affect the environmental implications of the crop production subsector.

The contractor's analysis of the workshop's findings led to a further categorization of each type of external event in terms of its primary impact on the crop production system. The resulting categories are as follows:

Input-Related
- Technology development
- Aggregate resource use
- Agricultural finance

Management-Related
- Technology use restraints
- Education/extension
- Environmental plans

Output-Related
- Economics - markets
- Residuals

System-Related
- Institutional
- Climate/weather

The identified exogenous factors, policy concerns and research needs are grouped within the categories even though their specific events are unique to each of the three types of external events. The exogenous factors are summarized here.

Input-related exogenous factors are those that affect the quantity and/or quality of inputs supplied to the crop producer and over which he has little direct control. The specific factors identified were the uncertain availability and questionable efficiency of selected resources; the potential conflicts in future aggregate demands for resources such as land, water, and energy; and the inadequacy of capital financing in the crop production subsector.

Management-related exogenous factors primarily involve the aggregate effects of the crop production system itself over which the individual producer has virtually no control. Two important economic or market-related factors are market instabilities (whether supply or demand induced) and irregular export demands. A third output related factor is the aggregate effects of the crop production system's residual output (vs. crop output) where the individual producer's effects are generally minor but the composite system's effects are consequential for the environment, and, thus, of public concern.

The final, system-related category of exogenous factors denotes those factors that may affect more than one major component of the crop production system. The panels identified three institutional factors: insufficient government coordination of environmental actions; inadequate agricultural representation in the development of local NPS plans; and insufficient basic science research from an institutional perspective. Lastly, uncontrollable climate and weather is decidedly a major exogenous factor affecting input use, management practices and the system's outputs--crops and residuals.

Many of these exogenous factors were cited by all or several regional panels. Regional panel emphases did in some instances vary importantly, e.g., climate/weather is of greatest concern in the Cornbelt/Lake States and the Great Plains. Some of these major regional differences are summarized in Exhibit VII-3.

H. Policy Concerns

Government policy is a second category of external events that directly or indirectly affect the crop production system and, thus, its environmental implications. Government policies may effectively modify or control the performance of the crop production system by implementing related programs to change input use, management practices, or output levels. Furthermore, government policies may be adopted to control or limit those exogenous factors that affect the crop production system.

No attempt was made during or after the workshop to define specific policies that would provide for environmental enhancements by the crop production system. Rather, the aim of the workshop was to identify policy issues, or simply policy concerns, which are of either present or future importance.

The policy concerns identified by the panels were, in subsequent analysis, also categorized according to their major crop production system impacts and by subject areas as presented in the exogenous factor summary above. An overriding aspect throughout the panels' discussion of policy concerns was their advocacy of policy formulation that would assure an acceptable balance between environmental pollution controls and needed crop yield-production levels, i.e., a balance between two national goals.

Major input-related policy concerns included the need for increased public support for technological developments affecting plant genetics, agricultural chemicals, environmentally designed equipment, and improved resource-use efficiency. Also, growing policy concerns involve aggregate resource use patterns, such as those for land, water and energy, that will adversely affect crop production and its associated environmental effects.

Management-related policy concerns include the need for improving the analysis of technology-use restraints, the need for public education/extension support to disseminate best management practices information, the need for improved guidelines for state and area-wide NPS planning, and the need for including implementation incentives in subsequent environmental programs.

Output-related policy concerns emphasized the need for two critical economic market developments: (1) the designing of supply-demand management options for improving market instabilities, and (2) the improving of the management of irregular export demands. Regarding residual-outputs, improved monitoring capabilities appear essential for measuring the success of and the additional needs for environmental controls. Further, improved analyses of residual control alternatives are needed to assure that all environmental media effects are adequately considered.

System-related policy concerns emphasize institutional matters, including policy actions that will: (1) improve government coordination, (2) enhance intermedia coordination, (3) assure agriculture representation and input in environmental planning, and (4) support environmentally related basic science research. Policies are also needed to improve weather predictions--short and long-term--and to support weather modification research that may enhance environmental management.

I. Research Needs

The third major category of external events that affect the crop production system is research development. In some cases, needed research may primarily involve policy analysis or exogenous factor assessments. The panels' findings, explained in detail in Section IX, were as follows.

Input-related research needs are extensive. For example, environmentally enhancing technology developments are possible through research for the advancement of germ plasm potentials, for the further development of biological nitrogen fixing capabilities, for the development of environmentally compatible agricultural chemicals, for the development of environmentally designed equipment, and for improved resource-use efficiencies, e.g., water and energy. In aggregate terms, improved assessments are needed of long-term demands for basic agricultural resources, i.e., land, water, energy, and capital, and the development of alternative plans for meeting those demands are recommended.

Management-related research needs are also extensive and generally more comprehensive than has been demonstrated in the past. A certain concern was evident in the workshop that technology-use restraints have previously been too narrowly assessed. Consequently, two types of more comprehensive analyses were proposed: (1) those for improved cost-benefit analyses of proposed technology-use restraints, and, (2) those to conduct cost-benefit analyses of alternatives to simultaneously achieving crop output and environmental goals. In the education/extension area, research is needed to plan for BMP implementation and to develop means for establishing site-specific best management practices. As environmental plans, e.g., 208 plans, are forwarded by state and local agencies, even more research will be needed to evaluate potential BMP's, to design integrated pest management systems, to plan BMP's compatible with NPS plans, and to determine the need for incentives.

Output-related research needs identified by the panels are especially complex, but solutions are critical if the potentially disruptive environmental effects of the crop production system are to be minimized. Foremost, the disruptive consequences of market instabilities indicate the necessity for three research needs: (1) to conduct analyses of policy alternatives for improving supply/demand management, (2) to assess crop output growth potentials under alternative environmental management strategies, and (3) to assess alternatives for improving the management of irregular export demands. The residual-output research needs included the design and development of a residual monitoring system, the assessment of the transport and fate of agricultural chemicals and sediment, and the design and evaluation of prospective residual control systems.

Finally, the system-related research needs included the design of methods and procedures for coordinating environmental activities among government agencies, the design of mechanisms to assure agricultural representation in applicable environmental planning, and the development of plans to expand and enhance environmentally related basic science research. Weather related research needs were limited to examining methods of obtaining and utilizing improved weather predictions for environmental management and to evaluating potential weather modification techniques for environmental management.

SECTION I

CONCLUSIONS

This study's conclusions are summarized below in relation to each of the study's four principal objectives. These conclusions reflect the Contractor's analysis of workshop assessments made by five regional area panels of crop production specialists. The five study regions--Northeastern, Southeastern, Cornbelt/Lake States, Great Plains and Western--were shown to differ importantly in their crop production trends and in their associated environmental effects. The relative importance of underlying exogenous factors, policy concerns, and research needs was also found to vary among the regions assessed.

Objective 1: Identify and assess regional crop production trends and their environmental implications

Within the context of the study's research approach, including its neccessarily subjective judgments about the future, each regional panel determined and assessed its region's major crop production trends and environmental effects. Although the regions differ in their dominant trends and environmental media concerns, the individual regional panels and the composite workshop came to the following conclusions.

Conclusions: The crop production subsector, regionally and nationally, can, with achievable developments, realize both the specified moderate growth output levels to 2010 and a consequent level of environmental effects more beneficial than the current one. Such achievable developments must include improved crop production inputs and more sophisticated management practices and residual controls.

The crop production subsector can also achieve the study's specified high growth scenario production levels, but in doing so, its environmental effects will be more deleterious than those of the moderate growth production levels. Further, the Cornbelt/Lake States region's attendant nutrient and pesticide pollutant effects and the Western region's water and soil salt accumulation pollutant effects would be more severe than present day effects. In other words, the predicted achievable developments in crop output potentials and in environmental management would not adequately compensate for the environmental effects of the relatively higher growth rates of the high growth vis-a-vis the moderate growth case.

Over seventy specific crop production trends in input use (quantity and quality), management practices, and residual controls were assessed regionally by the workshop panels as identified and discussed in Section VI. These trends were both individually and compositely assessed. First, each trend's extensiveness of use and intensiveness of environmental effects (relative to conventional techniques) were evaluated. Subsequently, their composite environmental implications were qualitatively rated.

An important facet of the composite analysis was that, although some potentially adverse individual trends are expected (e.g., increased pesticide use), there also exist compensating potentially beneficial trends (e.g., improved pesticide products and improved pesticide application methods). The net environmental effect can be beneficial relative to present environmental conditions even though individual adverse trends remain. Some such adverse trends are deemed essential so that national crop output goals can be realized, but, also, alternative practices can be employed to concurrently achieve environmental management goals.

In summary, each of the regional panels concluded that its region's sediment, nutrients, pesticides, and salt pollutant effects can be enhanced under the moderate growth scenario. The trends in input use, management practices, and residual controls that are projected to occur so that such environmental enhancements will be realized are as identified in Section VI.

Objective 2: Identify and assess, regionally, the major pollutants and their primary media (water, soil and air) effects

This objective was accomplished by completing three distinct environmental assessments within each region--for the current (1977) period, for the 2010 period under moderate growth, and for the 2010 period under high growth scenario production conditions. For example, the principal pollutants within each environmental medium were ranked, the same pollutants (and medium) were then ranked across all media--water, soil and air and, finally, each medium as a whole was ranked and rated relative to each other.

Conclusions: The crop producing regions of the U.S.--Northeastern, Southeastern, Cornbelt/Lake States, Great Plains and Western--have distinguishable and decidedly different crop production system environmental concerns. These differences can be expressed in terms of both the regions' major pollutants and the regions' primary media impacts--as shown specifically in Section V.

A consequent conclusion made by the panels was that regional improvements in environmental management will require regionally specialized programs. Such programs should focus on the major environmental concerns of each respective region. In particular, best management practices (BMP's) or integrated pest management programs, for instance, are not expected to be uniformly applicable among the regions. Indeed, even within regions, more site-specific criteria are necessary for the selection of desired management practices.

The regions' varied environmental media/pollutant concerns are also projected to change over time. For example, the Northeastern regional panel was most concerned presently about the water medium, especially its nutrient gains from crop production. However, by 2010 under moderate growth assumptions, the soil medium is projected to be of greatest concern because of continued soil losses and the predicted increasing concentrations of heavy metals caused by sludge disposal on cropland. In the Southeastern region, the main current-period environmental media concern is water because of nutrient, sediment and pesticide gains, even though soil loss (in the soil medium) is the single-most degrading environmental (pollutant) effect. Under high growth assumptions, the soil medium would become of equal concern with water by 2010. The Corn Belt/Lake States regional panel judged that its water medium is not the environmental medium most impacted by the crop production system, but that the concern for the soil medium will increase in the future--especially under the high growth case. Sediment and nutrient gains in the water medium are dominant now, although soil loss from the soil medium will become more critical.

The main environmental media concern in the Great Plains region, now and in the projected future, is the soil medium, particularly because of soil loss and, to a lesser extent, nutrient loss. Only this region considered the soil medium to be its current major environmental media concern, whereas the water medium was otherwise the principal regional concern. In the Western region, the water medium was of greatest concern because of both sediment and salt gains, and the salt gain pollutant effect is expected to increase in importance with projected growth. Although salt accumulation in the soil is the region's single-most important crop production pollutant effect, both now and in the projected future, water was considered the medium of most concern because of the combination of effects.

Objective 3: Identify, regionally, the major exogenous factors that influence the crop production system's environmental implications

In the study's workshop setting, each regional panel identified and discussed those exogenous factors outside the control of individual crop producers that are also determinants of the crop production system's environmental effects. Many of the panels' conclusions were nationally as well as regionally applicable.

Conclusions: Many regional and national exogenous factors are major determinants of the crop production system's levels of environmental effects. In order to improve environmental management in the crop production subsector, many could be publically, if not privately, controlled.

The principal national exogenous factors are summarized in Exhibit I-1. Such factors, e.g., inadequate capital financing, resource-use restrictions, and market instabilities, are directly linked to all of the crop production system's main components--inputs, management, and outputs. Consequently, these same exogenous factors can indirectly affect the system's environmental impacts. In some instances, public or private control of the exogenous factors (through policy and/or research developments) will potentially enhance environmental quality more effectively than direct controls within the crop production system.

These exogenous factors are also described in detail in Section VII which includes, also, an assessment of their important regional differences. For example, the Northeastern panel was most concerned about land uses that reduce the crop production system's capacity. The Southeastern regional panel was first concerned about the adequacy of education/extension efforts needed to develop and implement best management practices. The Cornbelt/Lake States panel rated export-market effects as its major exogenous factor concern, and the Great Plains panel identified government restrictions on input uses as a key factor affecting crop production. The Western regional panel rated water supply and use as its primary exogenous factor concern. As shown in the text, these same factors and others were also rated highly by several regions.

Objective 4: Identify, regionally, those pertinent policy concerns and research needs that can influence the crop production system's environmental implications

Separate regional panel evaluations were made to identify policy concerns and research needs that are germane to the crop production system's trends in input use, management practices and residual controls, and their associated environmental implications, and to those exogenous factors which may be publically controlled.

Conclusions: Important regional differences do exist in the priorities for specific policy concerns and research needs. Such differences should be recognized in subsequent policy formulations and research plans that seek to most effectively improve environmental management in the regional crop production subsectors.

The identified policy concerns are described in Section VIII and the research needs are presented in Section IX. They are also briefly described in Exhibit I-1, where their interrelationships are apparent when these concerns and needs are categorized by crop production system component. Furthermore, the policy concerns and research needs are frequently causally interrelated with the system's exogenous factors as is also shown.

The policy concerns and research needs identified by the regional panels are numerous; however, their priorities for consideration were not specifically established. Implicitly, the major environmentally related trends and the principal exogenous factors identified are a partial basis for further

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Exhibit I-1. Summary of major exogenous factors, policy concerns and research needs affecting the crop production systems

Crop Production System Component and Subject Area	Exogenous Factor	Policy Concern	Research Needs
INPUT-RELATED			
Technology development	. Uncertain resource availability . Questionable resource-use efficiencies	. Sustain plant genetics improvements . Support agricultural chemicals improvements . Foster equipment improvements . Support resource-use efficiency improvements	. Advance germ plasm potentials . Develop and extend plant biological nitrogen fixing capabilities . Develop effective, environmentally-compatible agricultural chemicals . Develop environmentally-designed farm equipment . Design and develop more water-efficient irrigation systems . Improve energy-use efficiencies in crop production
. Aggregate resource use	. Potentially inappropriate land use . Potentially declining water supplies . Unassured energy availability	. Subscribe to land uses more protective of agriculture . Improve upon aggregate water uses . Maintain energy supplies and forms	. Assess prospective long-term land use demands and design alternative land use plans . Assess prospective long-term water demands and design alternative water allocation plans . Assess prospective energy use demands and design alternative energy allocation plans . Develop alternative on-farm energy sources
. Agricultural finance	. Inadequate capital financing	. Improve agricultural credit and financing	. Design and appraise alternative methods of agricultural financing
MANAGEMENT-RELATED			
. Technology use restraints	. Restricted pesticide use . Potential fertilizer use constraints	. Improve analysis of technology use restraints	. Conduct improved cost-benefit analyses of proposed technology-use restraints . Conduct cost-benefit analyses of alternatives to simultaneously achieve crop output and environmental goals
. Education/ extension	. Unassured implementation of new management systems	. Support the public dissemination of environmental management practices	. Design education/extension plans for BMP implementation . Develop means for establishing improved site-specific best management practices
. Environmental plans	. Impending requirements for state and local environmental plans	. Establish guidelines for local environmental planning . Subscribe to implementation incentives	. Evaluate potential best management practices . Design and assess integrated pest management alternatives . Establish and assess preferred crop sequencing alternatives . Develop local BMP implementation plans compatible with NPS plans . Determine local needs for BMP's incentives
OUTPUT-RELATED			
. Economics-markets	. Market instabilities . Irregular export markets	. Advance the design of supply/demand management options . Subscribe to management of irregular export demands	. Conduct analyses of policy alternatives for improving supply/demand management . Assess crop output growth potential under alternative environmental management strategies . Assess alternatives for improving the management of irregular export demands
. Residuals	. Composite environmental effects	. Establish monitoring capabilities . Improve analyses of residual control alternatives	. Design and develop a residuals monitoring system . Assess the transport and fate of agricultural chemicals in the environment . Assess the incidence of soil erosion, and the transport and fate of associated sediment . Design and evaluate prospective residual control systems
SYSTEM-RELATED			
. Institutional	. Insufficient government coordination . Inadequate agricultural representation . Insufficient basic science research	. Improve government coordination . Enhance inter-media environmental coordination . Subscribe to more direct representation and input from agriculturalists in environmental planning . Support environmentally-related basic science research	. Design methods and procedures for coordinating intergovernments environmental activities . Design mechanisms to assure that agricultural representation and input are included in applicable environmental planning . Analyze multi-media interactions of environmental controls and delineate appropriate coordination requirements . Develop plans to expand and enhance environmentally-related basic science research
. Climate/ weather	. Uncontrollable climate/ weather	. Support weather prediction improvements for environmental management . Support weather modification research for environmental management	. Examine methods for obtaining and utilizing improved weather predictions for environmental management . Evaluate potential weather modification techniques for environmental management

Source: Developed by DPRA based upon information received from the regional panels.

determining needed priorities. Categorically, however, there exists the need for policy and research developments in every component of the crop production system, i.e., input-related, management-related, output-related, and system-related as outlined in Exhibit I-1.

An evident aspect of the study procedures was that the above stated objectives were sequentially addressed by the workshop in the order shown, although clearly, the evaluations implicitly involved concurrent consideration of most factors within each objective, e.g., trend assessments to 2010 implicitly required conceptual policy positions and research developments supportive of the projected trend. This became self-evident in the analysis when, in fact, the opportunity was given to identify and discuss the associated exogenous factors, policy concerns, and research needs. Each regional panel, during its evaluations, informally characterized a dynamic, future scenario in which presumed achievable developments would be made. These informal scenarios were not recorded, per se, except in terms of expected crop production trends in input use, management practices and residual controls. More explicitly, those exogenous factors, policy concerns, and research needs which are indeed of public concern have been identified as summarized in Exhibit I-1.

Finally, by integrating the above results and conclusions, the study showed that the regional crop production subsectors' growth levels and environmental effects can be effectively managed if achievable research developments and balanced output-environmental policies are implemented. Importantly, however, research developments and balanced output-environmental effects policies are needed as generally described in the study.

SECTION II

INTRODUCTION

The crop production subsector is the primary nonpoint source of pollution within the agriculture sector, and it is responsible for substantial pollution in the United States. Its principal pollutants are sediment, nutrients, pesticides, and salt, and they affect the three primary media--water, soil, and air.

In isolated, site-specific cases, crop production pollutants (e.g., pesticide run-off) have been cited as the principal cause of detrimental ecological effects. Generally, however, even though the subsector's pollution levels are substantial, they have seldom been solely responsible for major ecological damage to aquatic or terrestrial life, or ultimately, to human health. Of greater, future concern because of the projected growth in the crop production subsector is the increasing potential for the subsector's detrimental ecological effects. Both the existence of site-specific cases and the potential for high pollution levels in the aggregate are adequate reasons for further assessing the environmental implications of trends in the crop production subsector.

As the two preceding volumes of this report suggest, another concern germane to the crop production subsector of the United States is that its environmental effects differ regionally; hence, the assessment approach of this study was designed to determine those regional differences wherever they exist.

A. Scope of Study

This study for the U.S. Environmental Protection Agency sought to identify and assess those current and emerging trends in the U.S. crop production subsector that will have the most significant environmental implications. Such trends may have either beneficial or adverse implications relative to current crop production practices. The principal objectives of the study were:

(1) to identify and assess, on a regional basis, those major crop production subsector trends in input use, management practices, and residual controls and their environmental implications in both the short-term (1985) and the long-term (2010),

(2) to identify and assess, on a regional basis, the major pollutants and their primary media (water, soil and air) effects,

(3) to identify, on a regional basis, those exogenous factors (beyond the direct control of crop production subsector) that may affect some trends and, thus, have major indirect environmental implications for the respective regional crop production subsectors, and

(4) to identify, on a regional basis, those pertinent research needs and policy concerns that will affect the crop production subsector's expected environmental implications.

The study's assessment procedure included a national workshop evaluation comprised of five region-specific panels of agricultural professionals--Northeastern, Southeastern, Cornbelt/Lake States, Great Plains, and Western. Further, assessments were made for two alternative growth scenarios--moderate and high growth cases. These procedures were integral components of the study's scope of work, and they are described further below.

B. Research Approach

The primary assessments in this study were made by panels of agricultural professionals in a workshop setting. Based on an interim workshop report of regional-national data, stated analytical procedures, and evaluation forms, the workshop panels completed a series of assessments for an original list of trends, which were modified as desired. The assessments included both the evaluation of the individual trends' environmental effects, and their aggregate environmental implications. Similar assessments were made for each of the five regions; the specific procedures for these assessments are as summarized in Appendix A: Workshop Procedures.

The research approach of this study was fundamentally a modified Delphi technique in which panels of qualified experts systematically evaluated crop production trends and their environmental implications, both currently (1977) and into the projected future, under specified, alternate demand scenarios to 2010. Technically, the research approach could be replicated, although the "results" are clearly based upon the value judgments of the workshop participants. At best, value judgments are required for this type of futures-related study; thus, highly qualified panels of experts are critical to the determination of accurate and useful results.

The five regional panels of experts were chosen from among those recommended by the U.S. Environmental Protection Agency, the U.S. Department of Agriculture, and the Contractor's recommendations of both private and public sector representatives. Selection criteria required that the prospective participants be knowledgeable of both the crop production system and the environmental effects associated with it. The workshop participants are as listed in Exhibit II-1, by region, with a brief explanation of their professional affiliations and their areas of specialization. These participants were primarily involved in regional panel assessments, although they also participated in general sessions that added broader perspectives to the workshop's discussions.

A "national" assessment was made of the regional findings--in part via general session discussions at the workshop, and, in part, by a post-workshop analysis of the region-specific work books submitted by the chairman of each regional panel. DPRA resource personnel also attended each of the panel sessions and recorded supportive data and comments. Primarily, however, the national assessment is the composite of five regional assessments where both similarities and differences are clearly evident.

C. Regions

The workshop and related assessments of the crop production sector's trends were completed on a regional basis to reflect the wide range of regional climatic, topographic, soil, and other natural conditions within the U.S. that dramatically influence the crops grown and the crop production practices utilized by regional producers. These differences, in turn, result in varying environmental effects.

Five regions, consisting of aggregations of existing USDA farm production regions, were designated for the purposes of this study: Northeastern, Southeastern, Cornbelt/Lake States, Great Plains, and Western. Exhibit II-2 lists these regions, their comparable USDA farm production regions, and the states of which they are composed. A map delineating the regions is also presented in Exhibit II-3.

Both Alaska and Hawaii were excluded from this analysis. These states have relatively small amounts of cropland, e.g., less than .01 percent of the land in Alaska is classified as cropland, and their regional variations are so atypical that the areas' environmentally related assessments would require special consideration.

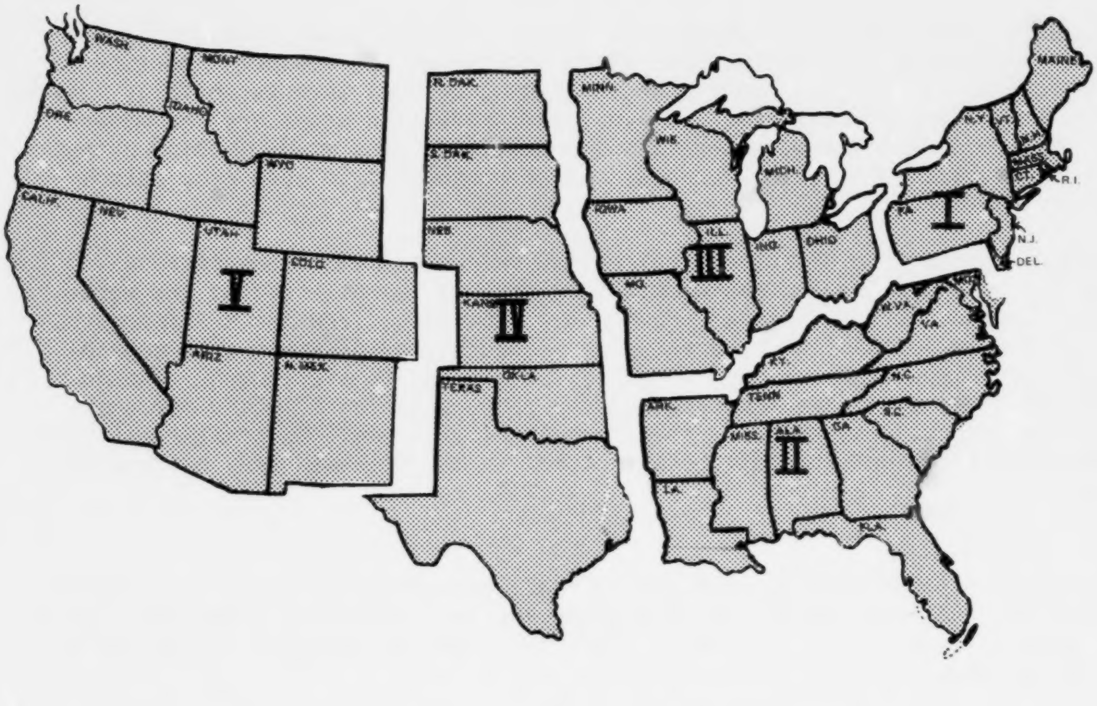
Exhibit II-1. Regional crop production trends assessment workshop participants

Name	Affiliation	Specialization
Region I: Northeastern		
Dr. Richard D. Black, Chr.	Department of Agricultural Engineering Cornell University	Soil and Water Resources Engineer
Dr. W. H. Allaway	Department of Agronomy Cornell University	Agronomist, Soil Conservation
Dr. William K. Griffith	National Potash & Phosphate Institute	Agronomist, Soil Fertility
Dr. Raymond J. Shipp	Department of Agronomy Pennsylvania State University	Agronomist, Extension
Dr. Duane C. Wolf	Department of Agronomy University of Maryland	Agronomist, Soil Biochemistry
Region II: Southeastern		
Dr. William Colville, Chr.	Department of Agronomy University of Georgia	Agronomist, Department Head
Dr. Harold D. Cobel	Department of Crop Science North Carolina State University	Weed Control Specialist
Dr. Ralph A. Leonard	Southern Piedmont Conservation Research Center, USDA	Agronomist, Soil Conservation
Dr. David C. Martens	Department of Agronomy Virginia Polytechnic Institute	Agronomist, Soil Fertility
Dr. Porter L. Russ	Agricultural Resource Development Branch, Tennessee Valley Authority	Economist, Fertilizer Specialist
Region III: Corn Belt/Lake States		
Dr. Earl O. Heady, Chr.,	Department of Economics Iowa State University	Economist, Production Economics
Richard Althaus	Mendota, Illinois	Farmer, General Crops
Dr. M. D. McGlamery	Department of Agronomy University of Illinois	Weed Control Specialist
Dr. Terry J. Logan	Department of Agronomy Ohio State University	Agronomist, Soil and Water Pollution
Dr. David L. Mick	Laverty Sprayers, Inc. Indianola, Iowa	Entomologist, Pest Control
Dr. L. M. Walsh	Department of Soil Science University of Wisconsin	Soil Scientist, Department Chr.
Region IV: Great Plains		
Dr. Larry S. Murphy, Chr.	National Potash & Phosphate Institute Manhattan, Kansas	Soil Fertility Specialist
Dr. Jack F. Carter	Department of Agronomy North Dakota State University	Agronomist, Department Chr.
Dr. William L. Powers	Kansas Water Resources Res. Institute Kansas State University	Water Resources Specialist
Mr. Ted Sherbeck	Ansley, Nebraska	Farmer, Crops and Livestock
Mr. Richard Wenberg	Soil Conservation Service USDA, Ft. Worth, Texas	Conservation, Water Management Engineer
Region V: Western		
Dr. R. S. Rauschkalb, Chr.	Agricultural Experiment Station University of California	Soil - Water Specialist
Mr. Tom Clark	Marana, Arizona	Farmer, Irrigated Crops
Dr. Claude L. Fly	Fort Collins, Colorado	Agronomist, Soils, Conservation
Mr. Robert M. Hoffman	Lodi, California	Horticulturalist
Dr. G. L. Horner	Department of Agricultural Economics Davis, California	Economist, Natural Resources
Dr. T. C. Tucker	Tennessee Valley Authority	Soils, Soil Fertility

Exhibit II-2. Designation of the regions for the assessment of environmental implications of regional crop production trends

Region	USDA Farm Production Regions	States
I. Northeastern	Northeast	Maine, New Hampshire, Vermont Rhode Island, Massachusetts Connecticut, New York, New Jersey Delaware, Maryland, Pennsylvania
II. Southeastern	Appalachian Southeast Delta State	Virginia, West Virginia, Tennessee Kentucky, North Carolina South Carolina, Alabama, Georgia Florida, Mississippi Louisiana, Arkansas
III. Cornbelt/Lake States (or Cornbelt)	Cornbelt Lake States	Ohio, Indiana, Illinois Missouri, Iowa, Wisconsin Michigan, Minnesota
IV. Great Plains	Northern Plains Southern Plains	North Dakota, South Dakota Nebraska, Kansas Oklahoma, Texas
V. Western	Mountain Pacific	Nevada, Idaho, New Mexico Arizona, Utah, Montana Colorado, Wyoming, Washington Oregon, California

Exhibit II-3. Five regional sectors utilized for analysis of environmental implications of crop production trends


WASH.
MONT.
IDAHO
ORE.
WYO.
CALIF.
NEV.
UTAH
COLO.
ARIZ.
N.MEX.
V
N.DAK.
S.DAK.
NEB.
KAN.
OKLA.
TEXAS
IV
MINN.
WIS.
MICH.
IOWA
ILL.
IND.
OHIO
MO.
III
MAINE
N.Y.
VT.
N.H.
MASS.
CONN.
R.I.
PA.
I
N.J.
DEL.
MD.
W.VA.
VA.
KY.
N.C.
TENN.
S.C.
ARK.
MISS.
ALA.
GA.
LA.
FLA.
II

SECTION III

CROP PRODUCTION SYSTEM

The crop production subsector within each of the study's five regions was first viewed as a closed system comprised of three main components: inputs, management practices, and outputs. The regional panels assessed trends and developments related to these three crop production system components.

A. System Definition

The crop production system is depicted conceptually in Exhibit III-1. Inputs such as cropland, nutrients, pesticides, and water are variable factors whose quantities and qualities can be at least partially controlled by crop producers. 1/ Management practices are also controllable, and such practice categories include: multi-season management, crop season management, and noncrop season management. Outputs, including both crops and residuals, constitute the third main component of the system.

Although traditional crop production system analysis makes crop output the primary variable of concern, this study focuses on the residuals portion of the outputs; thus, this study's regional crop outputs were essentially "given" values on a region-nation basis, i.e., the production necessary for moderate growth or high growth scenarios as projected. The study's chief output focus was, indirectly, the residual output consequent to such crop output requirements.

Although beyond the direct control of the crop production subsector, a variety of exogenous factors were also discussed and assessed by the workshop panels. Factors such as groundwater depletion, land-use developments, water rights legislation, and rates of technology advancement were considered. The importance of such variables should not be overlooked. Though they at times may prove too conceptually complex or too illusive for quantifiably exacting assessment, these variables may result in greater environmental implications than do those included in the assessed crop production

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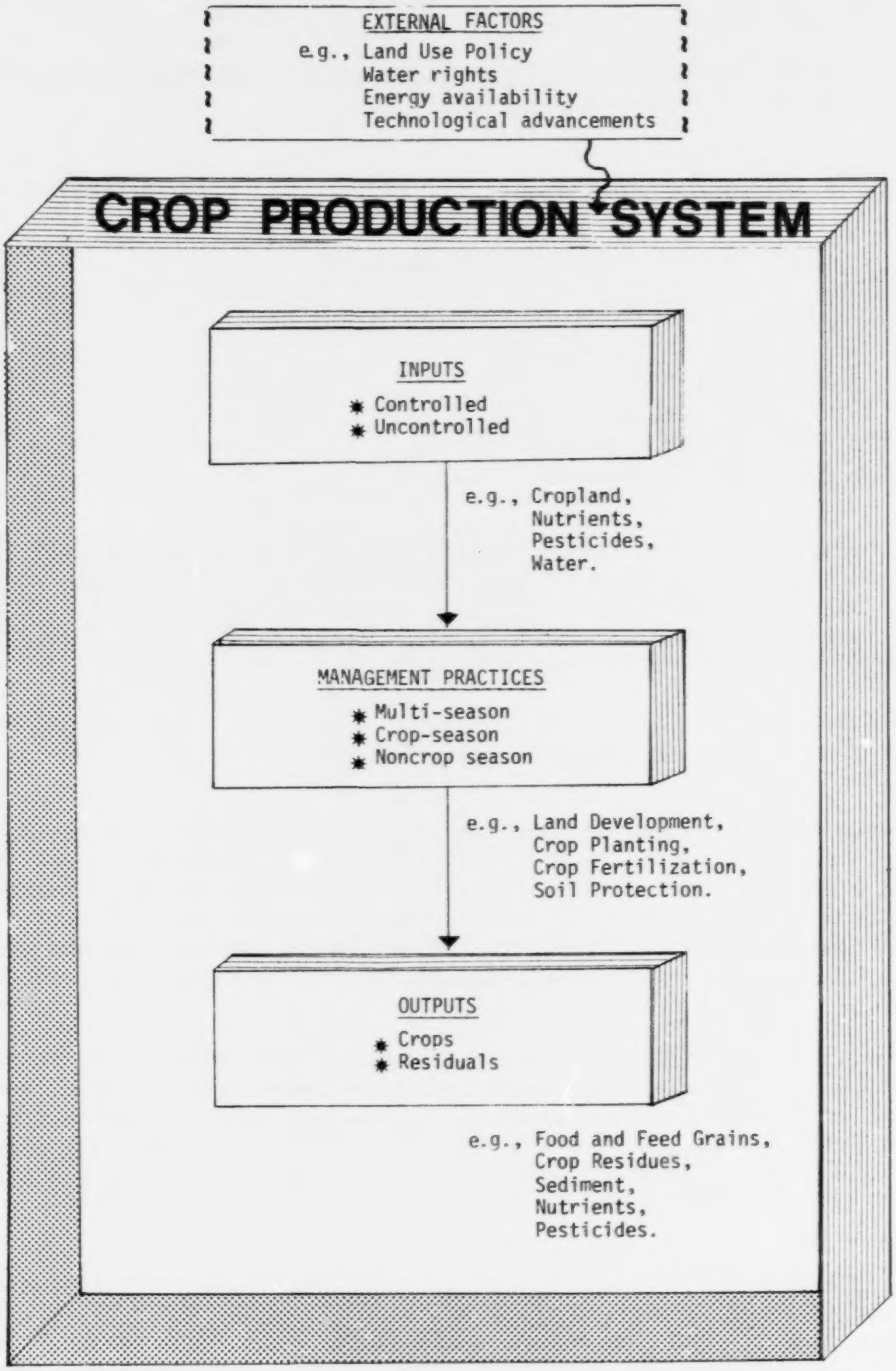
1/ Uncontrollable variables, e.g., rainfall amounts and timing, solar radiation, and land capability at a given location, are also important, but they will be viewed as internal factors characterizing the overall crop production system in each region.

Exhibit III-1. Schematic of the crop production system


EXTERNAL FACTORS
e.g., Land Use Policy
Water rights
Energy availability
Technological advancements
CROP PRODUCTION SYSTEM
INPUTS
✱ Controlled
✱ Uncontrolled
e.g., Cropland,
Nutrients,
Pesticides,
Water.
MANAGEMENT PRACTICES
✱ Multi-season
✱ Crop-season
✱ Noncrop season
e.g., Land Development,
Crop Planting,
Crop Fertilization,
Soil Protection.
OUTPUTS
✱ Crops
✱ Residuals
e.g., Food and Feed Grains,
Crop Residues,
Sediment,
Nutrients,
Pesticides.

system's components. Although beyond the scope of this study's analysis, in some instances such "exogenous" factors are consequential enough to justify separate, related analysis to indicate their potential environmental implications.

In summary form, the crop production system can also be characterized in terms of a general production function:

$$O(C,R) = F(I_1, I_2, \ldots, MP_1, MP_2, \ldots, RT_1, RT_2, \ldots \mid \text{EXTERNAL FACTORS})$$

where

O = Output
C = Crops
R = Residuals
I_i = Inputs, $i=1,2,\ldots$
MP_j = Management Practices, $j=1,2,\ldots$
RT_k = Residual Treatments, $k=1,2,\ldots$

In this relationship, the inputs, management practices, and residual treatments are regarded as controllable production factors that affect crop and residual outputs. The external factors, beyond producer control, are considered in this analysis to remain constant or to vary systematically in relation to the growth scenario projections.

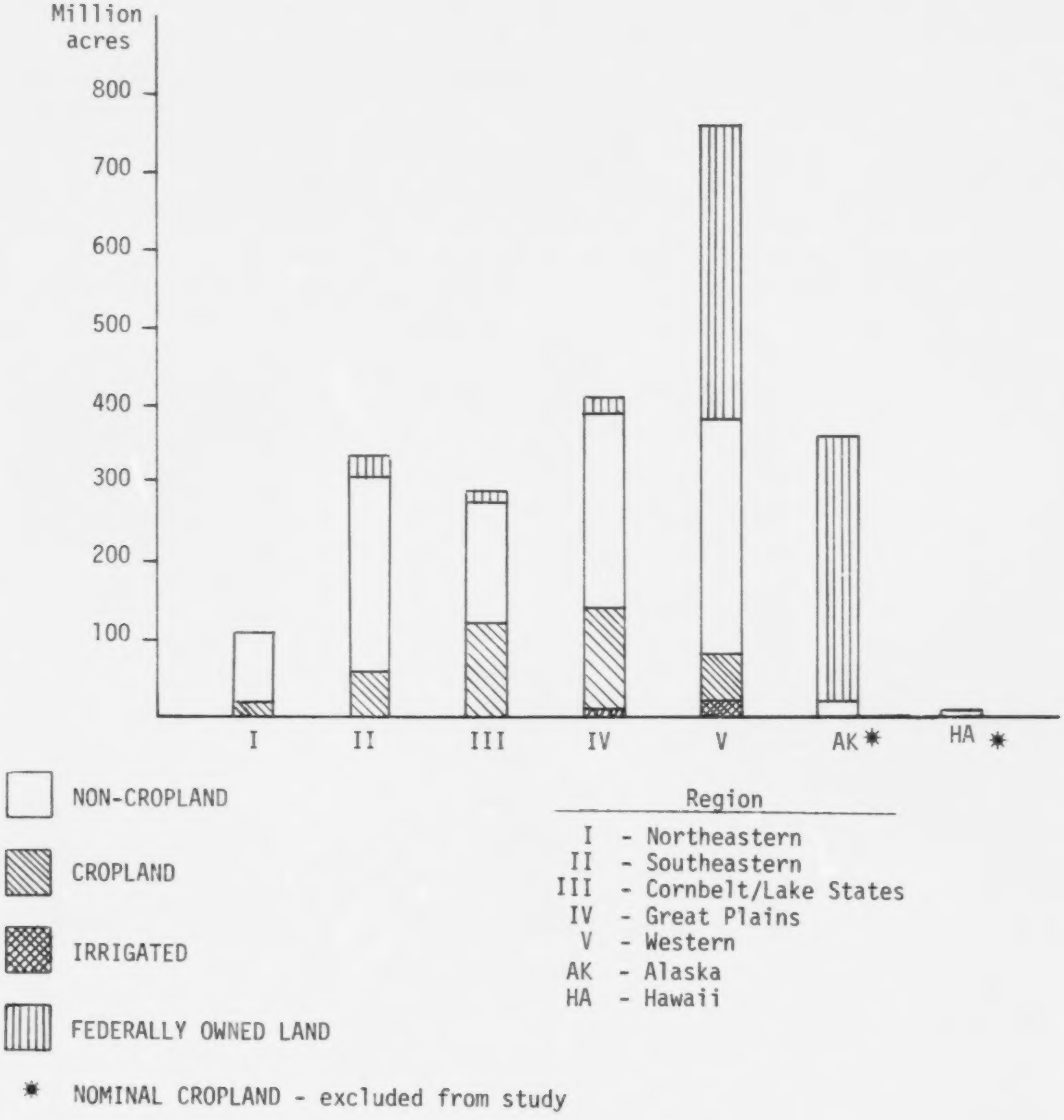
B. Regional Characteristics

Each of the five study regions--Northeastern, Southeastern, Cornbelt/Lake States, Great Plains, Western--has unique underlying climatic, topographic, soil and other natural characteristics that can affect the environmental implications of their respective crop production subsectors. A series of illustrations are presented below to indicate both similarities and differences in the regions' underlying characteristics and their crop production subsectors.

In an overview, the total land area and its uses are indicated by region in Exhibit III-2. First, the amount of federally owned land is shown, and the remainder is divided into cropland and noncropland uses--including irrigated cropland (1974 basis). This chart does not reflect the relatively small amounts of irrigated farmland in other than the Western and Great Plains but irrigated cropland does exist elsewhere and is becoming increasingly important.

Further, the regional characteristics of major importance to the study are summarized in the next five regional exhibits (Exhibits III-3 to III-7), which show land use and crop season profiles for each study region. In

Exhibit III-2. Total land area and types of land use, by region, U.S. (1974 basis)



Region

I - Northeastern
II - Southeastern
III - Cornbelt/Lake States
IV - Great Plains
V - Western
AK - Alaska
HA - Hawaii

Sources: U.S. Department of Agriculture, U.S. Environmental Protection Agency, "Control of Water Pollution from Cropland," Volume II-An Overview, June 1976.
U.S. Department of Commerce, Bureau of the Census, 1969, Census of Agriculture.

Exhibit III-3. Land use and crop season profiles, Region I: Northeastern

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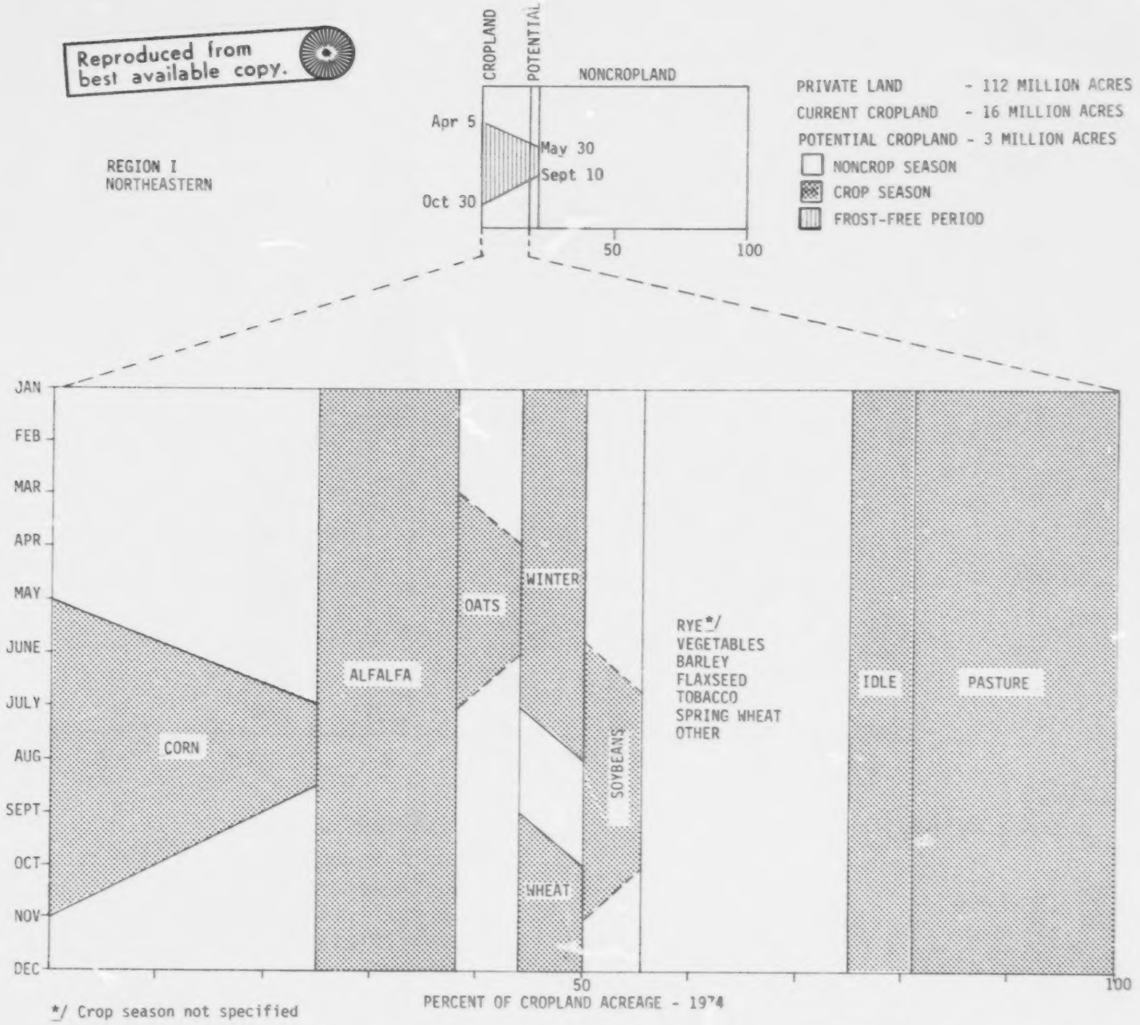


*/ Crop season not specified

Selected Environmental Factors

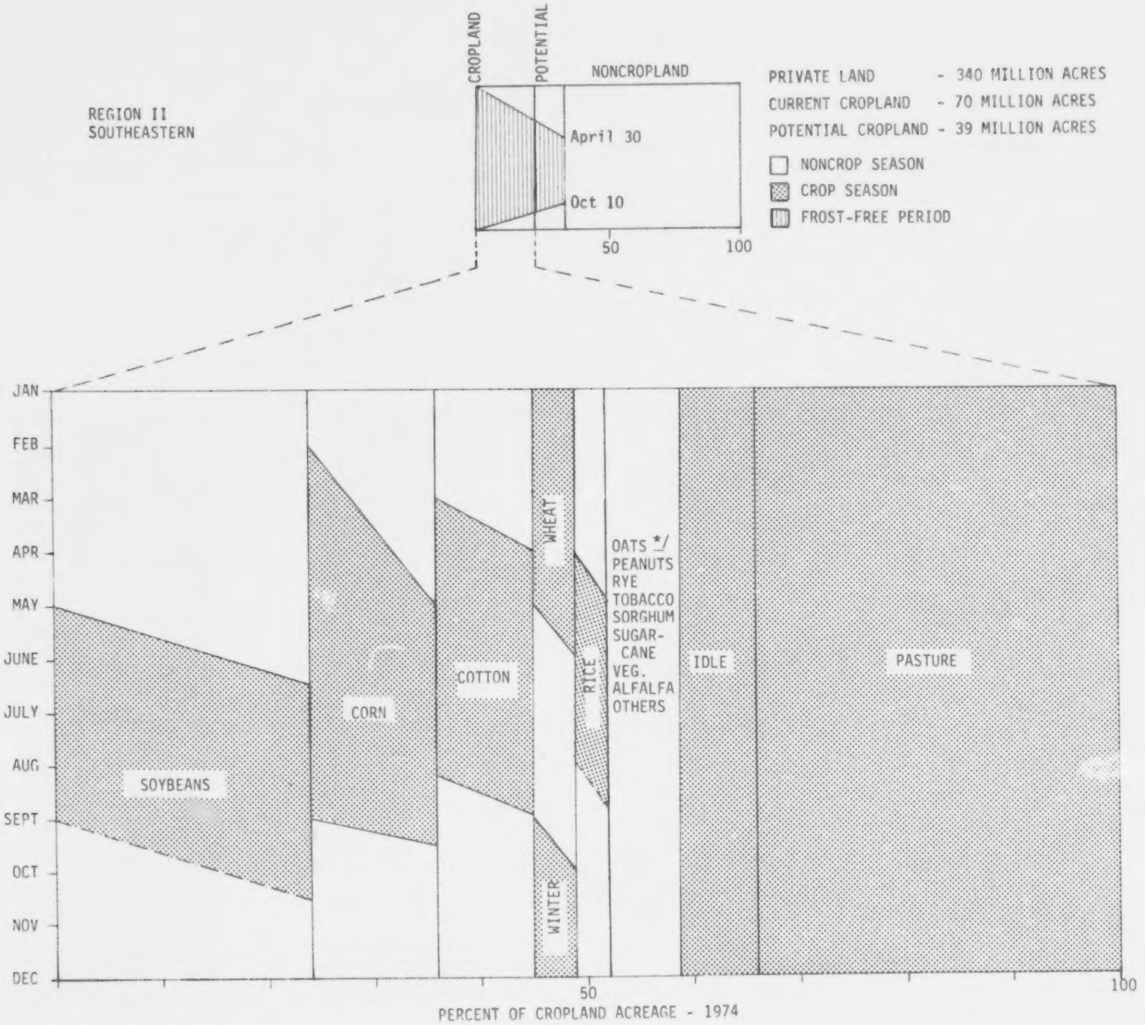
Annual Potential Runoff	~ 3"
Growing Season Potential Runoff	~ 1.5"
Cropland on which erosion dominant limitation	~ 10%
Contribution of cropland to sediment	Moderate
Rainfall erosivity - R	~ 125
Annual potential percolation	> 7"
Snowfall	10-100"
Frost penetration	10-72"
Potential loss of fall applied nitrogen	~ 30%
Potential loss of spring applied nitrogen	~ 10%

Rainfall primarily during growing season

Source: Prepared by Development Planning and Research Associates, Inc.

Reproduced from best available copy.

Exhibit III-4. Land use and crop season profiles, Region II: Southeastern



*/ Crop Season not specified

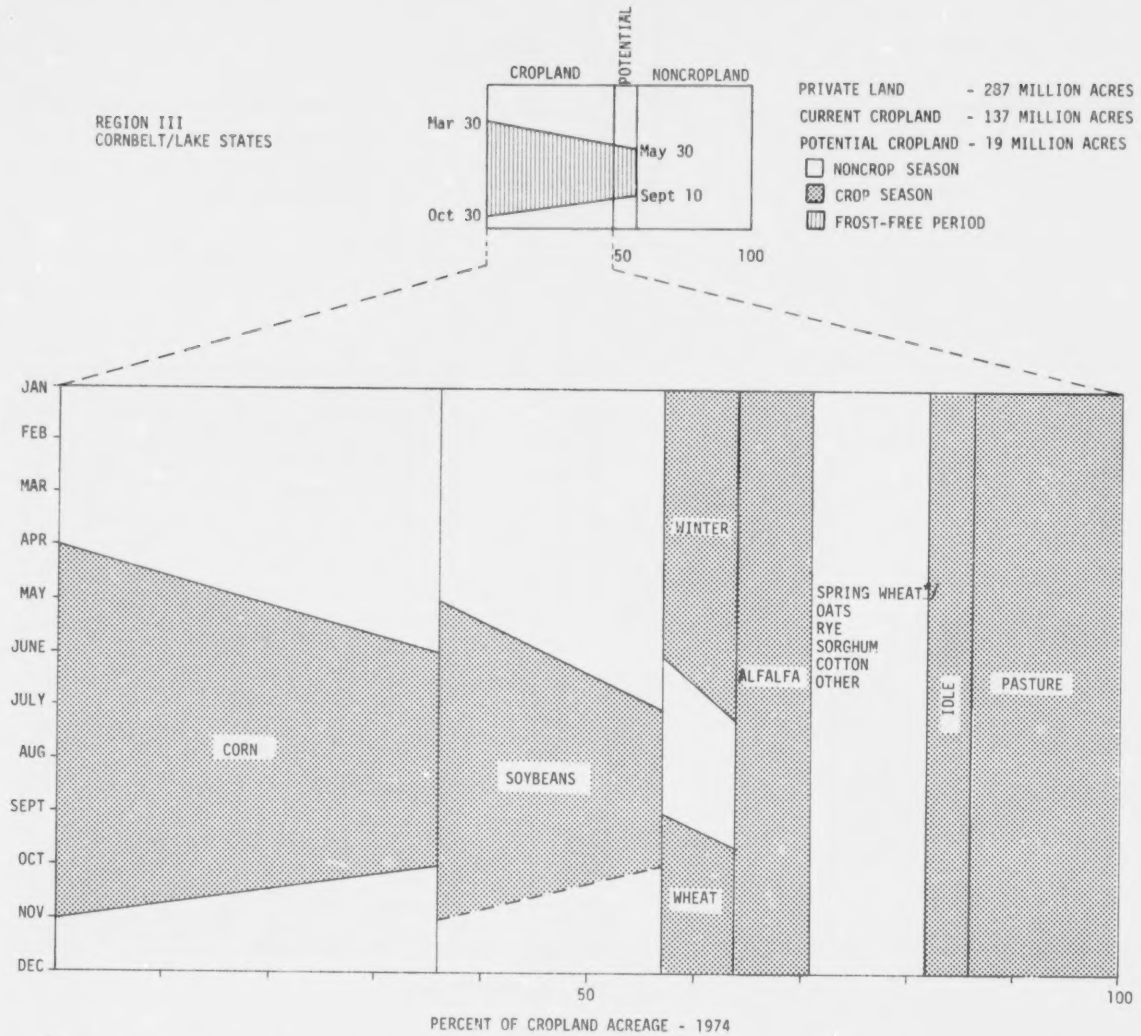
Selected Environmental Factors

Annual Potential Runoff	∿ 5"
Growing Season Potential Runoff	∿ 3"
Cropland on which erosion dominant limitation	∿ 10%
Contribution of cropland to sediment	Moderate
Rainfall erosivity - R	∿ 300
Annual potential percolation	> 7"
Snowfall	0-24"
Frost penetration	0-10"
Potential loss of fall-applied nitrogen	∿ 50%
Potential loss of spring applied nitrogen	∿ 10%

Rainfall ranges from primarily during growing season to evenly distributed throughout the year
Extent of double cropping unknown

Source: Prepared by Development Planning and Research Associates, Inc.

Exhibit III-5. Land use and crop season profiles, Region III: Cornbelt/Lake States

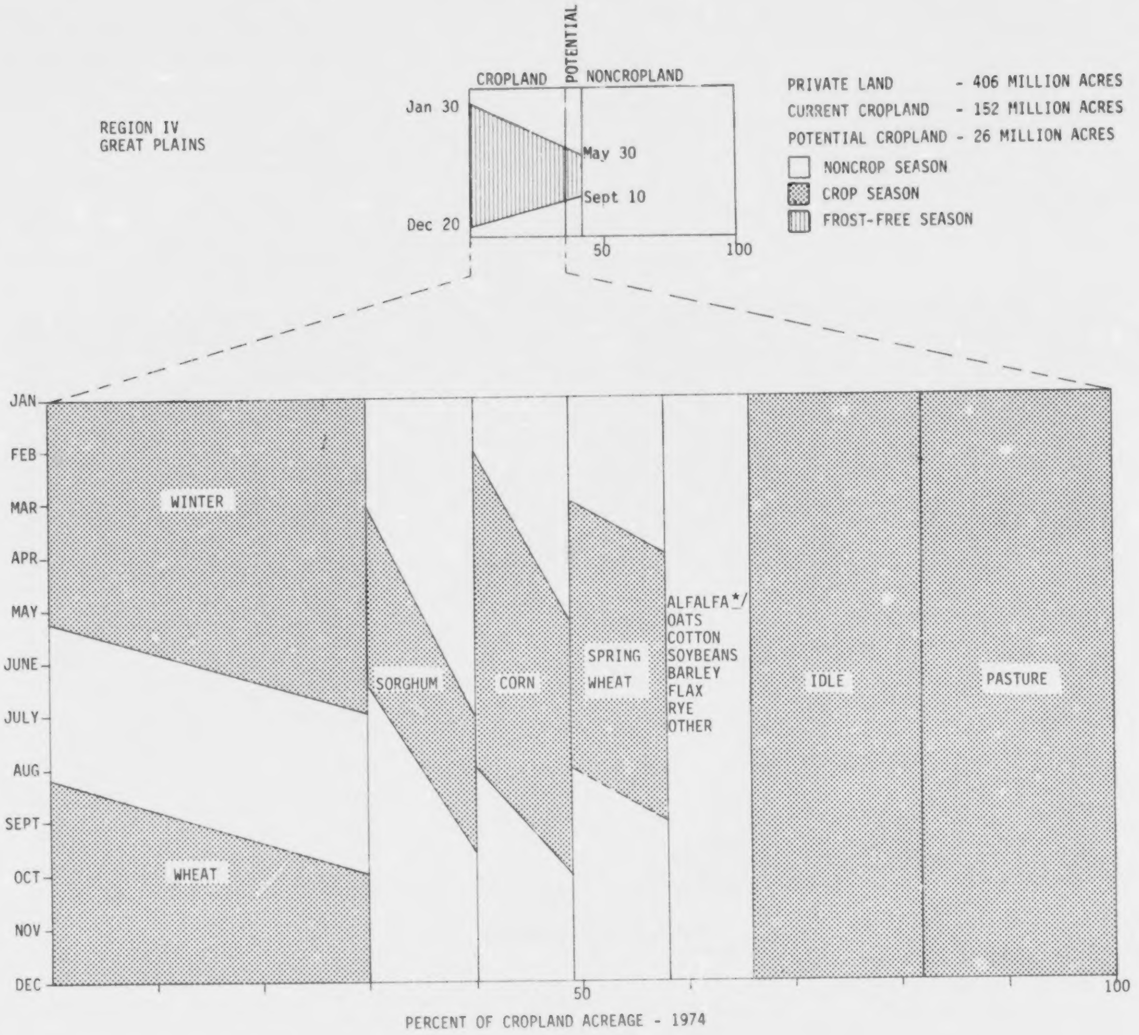


*/ Crop season not specified

Selected Environmental Factors	
Annual Potential Runoff	~ 3"
Growing Season Potential Runoff	~ 2"
Cropland on which erosion dominant limitation	~ 30%
Contribution of cropland to sediment	High to very high
Rainfall erosivity - R	~ 150
Annual potential percolation	~ 5"
Snowfall	12-60"
Frost penetration	6-50"
Potential loss of fall applied nitrogen	~ 30%
Potential loss of spring applied nitrogen	< 10%
Rainfall primarily during growing season	

Source: Prepared by Development Planning and Research Associates,

Exhibit III-6. Land use and crop season profiles, Region IV: Great Plains



*/ Crop season not specified

Selected Environmental Factors:

Annual Potential Runoff	~ 3"
Growing Season Potential Runoff	~ 2"
Cropland on which erosion dominant limitation	~ 20%
Contribution of cropland to sediment	Moderate
Rainfall erosivity - R	~ 150
Annual Potential percolation	< 1"
Snowfall	0-36"
Frost penetration	0-50"
Potential loss of fall applied nitrogen	< 10%
Potential loss of spring applied nitrogen	~ 0%

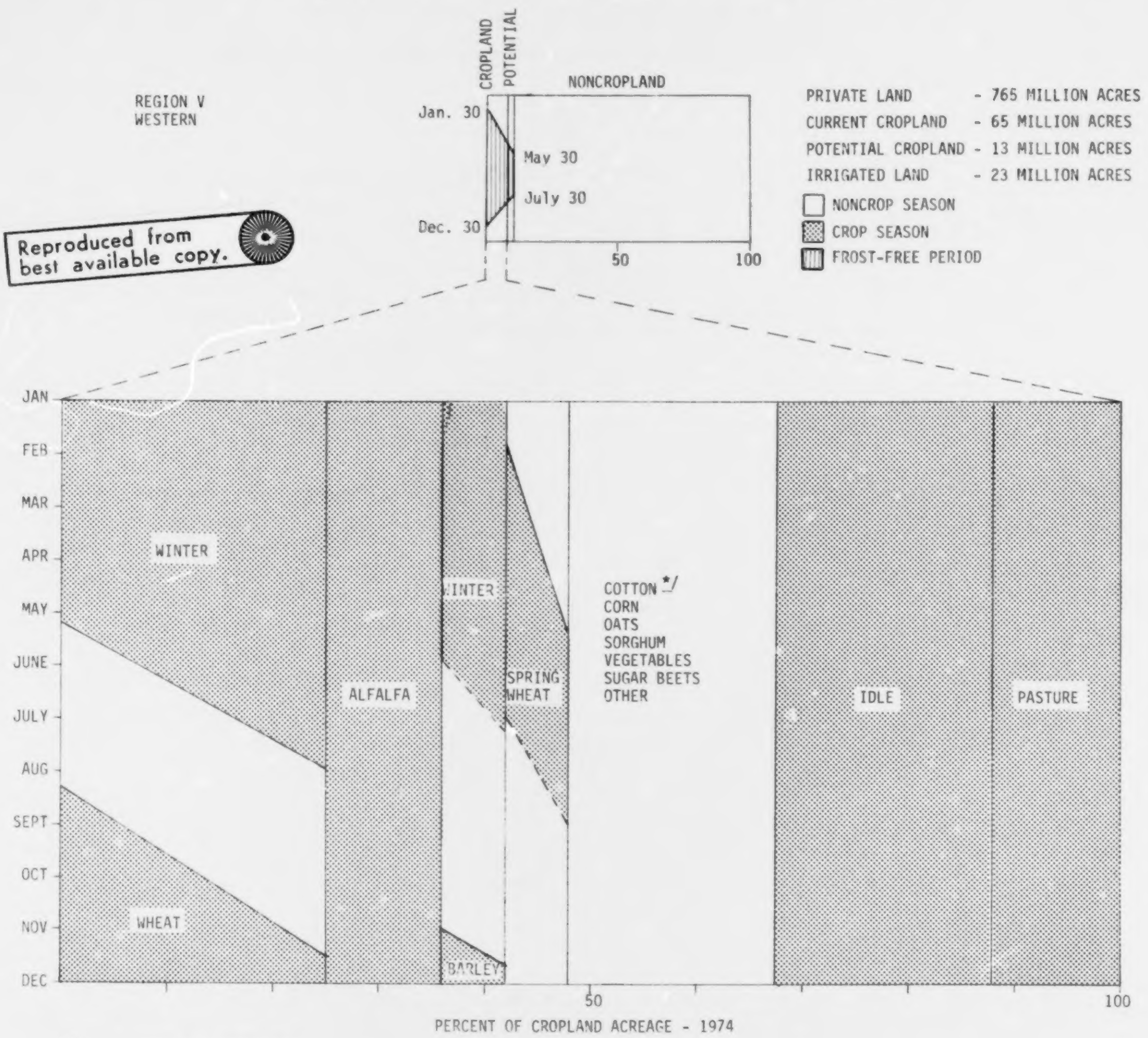
Rainfall ranges from predominantly in crop season to predominantly in noncrop season

Significant area in fallow

Source: Prepared by Development Planning and Research Associates, Inc.

Exhibit III-7. Land use and crop season profiles, Region V: Western

Reproduced from best available copy.



*/Crop season not specified

Selected Environmental Factors

Annual Potential Runoff	--
Growing Season Potential Runoff	--
Cropland on which erosion dominant limitation	< 10%
Contribution of cropland to sediment	Low
Rainfall erosivity - R	25
Annual potential percolation	--
Snowfall	0-400"
Frost penetration	0-50"
Potential loss of fall applied nitrogen	--
Potential loss of spring applied nitrogen	--

In 1974, 36 percent of the cropland was irrigated.

Detailed 1974 data are not available to identify completely the percentage of each crop irrigated.

Principal crops irrigated include vegetables, wheat, barley and cotton.

Source: Prepared by Development Planning and Research Associates, Inc.

particular, the following principal information is presented: (1) the proportions of cropland, potential cropland, and noncropland, (2) the range of the frost-free period within each region, (3) the proportions of cropland (1974) in specific commercial crops, idle (including soil improvement), and pasture, and (4) the crop season and the noncrop season of each major crop.

Within each regional exhibit, the larger diagram shows the cropland-use profile, and the crop season range for each crop is designated by the shaded areas corresponding to the calendar year on the vertical axis. The differences in the length of the crop season are principally a function of climate variation within the region.

Other environmentally related data such as precipitation, potential runoff, and erosion characteristics are also summarized in each regional exhibit. Data are not available to determine the extent of double-cropping or multiple-cropping and the extent to which cover crops are used during the "noncrop season" as an erosion control practice.

Additional data and more detailed descriptions of regional crop production characteristics are presented in Appendix C.

SECTION IV

GROWTH SCENARIOS: PRESENT TO 2010

Substantial growth in the aggregate level of U.S. agricultural output is generally expected--particularly in the level of crop production output to 2010. Quantitative projection models have been developed for various agricultural products under alternative assumptions concerning demand variables such as population, gross national product, disposable income, technological advancements, international trade, and other economic conditions. A tacit, further assumption is that these projected demands can be supplied by the U.S. agriculture sector.

A. Determination of Crop Production Growth Indexes

This study required a firm baseline growth scenario to which trends and developments within the crop production subsector could be associated and their environmental implications assessed. To characterize the growth scenario crop production indexes were derived. The general approach for deriving the indexes involved the use of crop production weights developed by the National Economic Analysis Division, ERS, USDA [1] that convert physical units of major crops, obtained from OBERS [2] projections, to standard crop units. The physical production units were estimated for a moderate demand scenario in 1985 and 2010. Indexes were developed for five major production regions in addition to the U.S.

It should be noted that the OBERS estimates reflect key demand variables. Such variables for the moderate growth (demand) scenario are summarized in Exhibit IV-1.

As indicated, the U.S. population is expected to increase from the 1972 level of about 210 million to 235 million in 1985, and 281 million in 2010 (Series E. projections, U.S. Bureau of the Census). The Gross National Product (GNP) is expected to increase to $2,890 billion by 2010 (1958 dollars) based on the assumptions that output per man hour will increase 2.9

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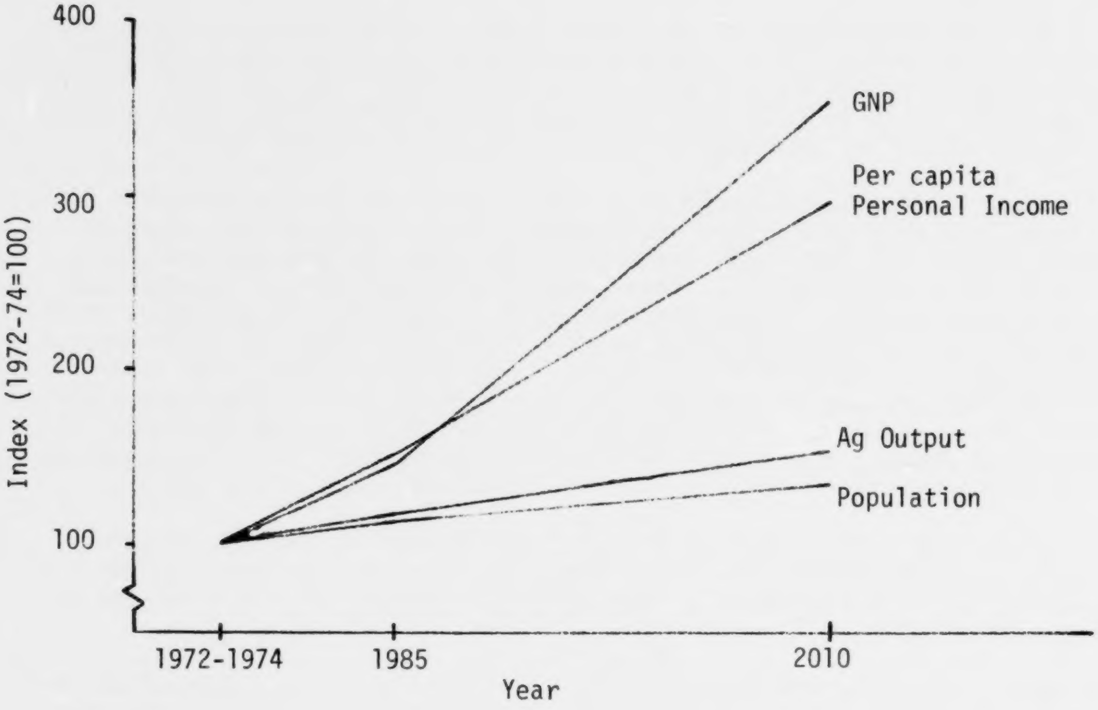
[1] U. S. Department of Agriculture, Economic Research Service, Agriculture in the Third Century, 1976. (ERS is now the Economics, Statistics and Cooperative Service.)

[2] U. S. Water Resources Council, OBERS, 1972 OBERS Projections Supplement, 1975.

Exhibit IV-1. Moderate growth scenario projections to 2010: population, gross national product, per capita personal income and agricultural output index



Variable	Unit	1972-74	Index (1972-74 = 100)		
			Current	1985	2010
Population	Million	210.4	100	111	134
Gross National Product	Billion of 1958 $	817.0	100	147	354
Per Capita Personal Income	1958 $	3,155.0	100	150	297
Agricultural Output Index (with Livestock)	1967=100	110	100	118	151

Sources: U.S. Department of Agriculture, Economic Research Service, Agriculture in the Third Century, 1976.
U.S. Water Resources Council, OBERS, 1972 OBERS Projections Supplement, 1975.

percent annually and that total manhours worked will decrease at a rate of 0.35 percent per year. Per capita personal income, an alternative measure of economic growth, is expected to increase to $9,370 (1958 dollars) by 2010.

The specific methodology for developing future crop production indexes involved three tasks. First, production of major crops was tabulated for the agricultural regions and the U.S. in the years 1973, 1985 and 2010. 1/ The production levels in 1973 (baseline) were obtained from USDA; OBERS projections were used for estimated production levels in 1985 and 2010.

The second task required conversion from physical units of a crop into a standardized crop unit. This was completed by multiplying 1967 constant price weights for individual products by the quantity of production for a crop in 1973, 1985 and 2010. After each crop production was standardized by the price weights, these standardized levels of crops, e.g., corn, wheat, soybeans, were combined to yield an aggregate crop production level for the crop production regions and the U.W. in 1973, 1985 and 2010. The 1973 standardized production level was adjusted to reflect the relationship between the average crop production index of 1972-1974 and the 1973 crop production index. This, in effect, provided an average 1972-1974 standardized crop production level for the crop production regions and the U.S.

The final task simply involved dividing the regional and U.S. aggregate standardized production levels for 1985 and 2010 moderate demand by the average 1972-1974 aggregate standardized crop production. This yielded an index for 1985 and 2010 where 1972-1974 = 100.

It should be noted that this methodology for developing crop production indexes is the same as that used by the National Economic Analysis Division of USDA in making their projection. Again, the 1967 constant price weights for standardizing production of various crops were obtained from their files.

B. National and Regional Growth Projections

The aggregate levels of agricultural production (including livestock) under moderate growth assumptions for 1985 (short term) and 2010 (long term) are projected to increase from an index base of 100 in 1972-74 to 118 and 151 in 1985 and 2010, respectively. More particularly for this study, growth estimates were made for the crop production subsector only, and these are indicated in Exhibit IV-2. The level of crop production under moderate growth assumptions was projected to increase from an index base of 100 in 1972-74 to 122 and 171 in 1985 and 2010, respectively. Thus, the crop production subsector is projected to grow relatively more rapidly than the entire agriculture sector.

1/ Corn, wheat, soybeans, sorghum, oats, barley, cotton, tobacco, rice.

Exhibit IV-2. Crop production indexes for the U.S. and specified regions moderate and high growth scenarios for 1985 and 2010 (1972-74 = 100)

U.S. and Region	CROP PRODUCTION INDEX[1/] Average 1972-1974	Moderate Demand 1985	Moderate Demand 2010	High Demand[2/] 1985	High Demand[2/] 2010	% Change in Index Mod. to High 1985	% Change in Index Mod. to High 2010
UNITED STATES	100	122	171	143	196	17%	15%
REGIONS:							
I. Northeastern	100	126	174	147	199	17%	14%
II. Southeastern	100	118	176	139	201	18%	14%
III. Cornbelt/ Lake States	100	138	191	159	216	15%	13%
IV. Great Plains	100	103	144	124	169	20%	17%
V. Western	100	120	156	141	181	18%	16%

Note: Recent U.S. Crop Production Indexes (1972-1974 = 100): 1975 = 106
1976 = 106
1977 = 113

[1/] Most indexes are calculated using the 1967 constant price weights with base production period of 1972-1974. This procedure is similar to that used by NEAD-USDA and is used to calculate all the above U.S. indexes and moderate demand regional indexes as production data was available from: USDA for 1972-74, OBERS for moderate demand U.S. and regions, and previous DPRA publication U.S. high demand.

[2/] Insufficient regional data were available to estimate high demand crop production indexes by the above procedure and they were derived based on the assumption that each region will contribute the same amount to changes in the U.S. crop production index. Thus a moderate to high demand change of 20 points in the U.S. index would suggest each region will increase its index by 20 points.

For purposes of comparison, the national growth indexes under high growth assumptions for the crop production subsector show growth from the index base of 100 in 1972-74 to 143 and 196 for 1985 and 2010, respectively, a 15 percent increase over the moderate growth baseline case. This additional "demand" arises primarily from the assumption that greater exports of food and feed grains could occur.

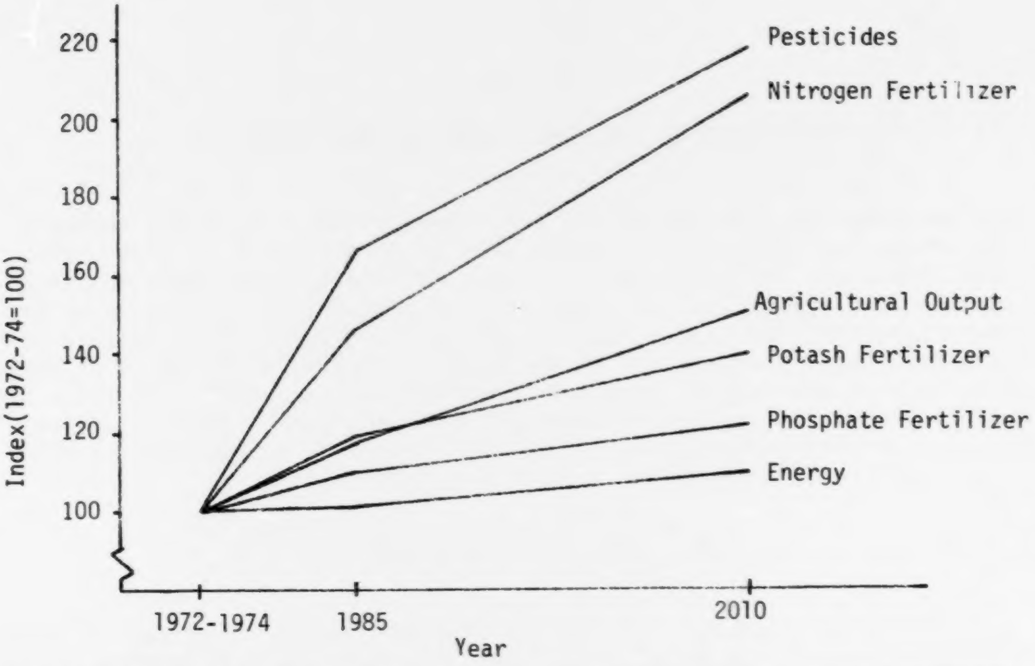
Regional crop production indexes for the moderate and high growth scenario, tabulated in Exhibit IV-2, vary by region. For example, under either scenario, the greatest increase is projected for the Cornbelt/Lake States region, with an index of 191 in 2010 under moderate and 216 under the high growth scenario. With moderate growth, the indexes for the other regions in 2010 varied from 144 in the Great Plains to 176 in the Southeastern region. Under the high growth scenario, increases of 13 to 17 percent greater than for moderate growth are projected.

C. Input Requirements

In order to meet the projected levels of output as shown under the moderate growth scenario, various resources (inputs) are assumed to be available in ample quantities for the crop production subsector. A national perspective of the amounts of major inputs that will be required to achieve the moderate growth production levels above are, in turn, projected as shown in Exhibit IV-3. By 2010, these inputs will accordingly increase nationally as follows: nitrogen fertilizer, 106 percent; pesticides, 118 percent; energy, 10 percent; and harvested cropland, 14 percent. Each of these projections was derived from the national baseline scenario, where, further, numerous additional assumptions were required within the ERS and OBERS models concerning factors such as the average productivity (yields) of crops and the average quality of new cropland. The regional evaluation workshop panels were not required to utilize the national input projections as representative of their individual regions. Rather, input-use trends were qualitatively assessed, separately, in each region.

Obviously, numerous other scenarios of growth and means of achievement are possible. Again, however, a specified and firm baseline scenario of macrolevel production requirements was needed for this study so that the evaluation workshop could systematically evaluate probable trends and developments within the crop production system that would likely occur in meeting the overall crop production levels as "specified" by the baseline scenario.

Exhibit IV-3. Moderate growth scenario projections to 2010: cropland harvested, fertilizer, pesticides, energy and agricultural output index



Variable	Unit	1972-74	Index (1972-74 = 100)		
			Current	1985	2010
Cropland Harvested	Million acres	311	100	102	114
Fertilizer					
Nitrogen (N)	Million of tons	8.2	100	146	206
Phosphates	Million of tons	5.0	100	110	122
Potash (k_2O)	Million of tons	4.7	100	119	140
Pesticides	Million lbs		100	166	218
Energy	Billion gals	8.0	100	101	110
Agricultural Output Index	1967=100	110	100	118	151

Sources: U.S. Department of Agriculture, Economic Research Service, Agriculture in the Third Century, 1976.
U. S. Water Resources Council, OBERS, 1972 OBERS Projections Supplement, 1975.
DPRA projections

SECTION V

ENVIRONMENTAL CONCERNS: CURRENT AND PROJECTED

Each workshop panel evaluated the environmental effects of its region's crop production subsector for three sets of conditions. In particular, these conditions included specifications of inputs, management practices, and outputs corresponding to: the current period (1977) level, a moderate growth level in 2010, and a high growth level in 2010. This Section indicates each panel's assessment of the potential pollutant effects of these three sets on the primary environmental media--water, soil, and air. Section VI presents the panels' judgements concerning the relative changes in inputs, management practices, and outputs that will be realized in 2010 under moderate or high growth production conditions.

A. The Evaluation Procedure

To determine the regional rankings of the crop production subsector's environmental effects on soil, water, and air, each panel followed a three-step procedure and recorded its judgments on an assessment form such as is presented in Exhibit V-1 for the Southeastern Region. To illustrate:

Step 1: Each panel ranked its region's environmental concerns for the three media under current and future growth assumptions. (The illustrated Southeastern panel form, for instance, shows nutrient gain, soil loss, and pesticide drift to be the foremost concerns in the water, soil, and air media, respectively.)

Step 2: Each panel then determined the relative importance of the pollutants among the three media. (The Southeastern panel ranked soil loss the most important and nutrient gain in water next in importance.)

Step 3: Each panel completed the procedure by determining the relative extent to which each primary environmental medium was affected by the crop production subsector. (The Southeastern regional panel judged water to be most affected, soil slightly less so, and air significantly less so.

The three-step procedure, in general, showed that four of the five regional panels--Northeastern, Southeastern, Cornbelt/Lake States, and Western--considered the water medium to be that of greatest current environmental

Exhibit V-1

Form 1

Region: Southeastern

Time Period: Current

REGIONAL CROP PRODUCTION SUBSECTOR'S ENVIRONMENTAL CONCERNS ASSESSMENT FORM

I. Rank of Environmental Concerns by Medium

	Water		Soil		Air	
Environmental Concern 1/	Effect	Rank	Effect	Rank	Effect	Rank
Sediment	Sediment Gain	2	Soil Loss	1	Dust/Particulates	2
Nutrients	Nutrient Gain	1	Nutrient Loss	2	Gaseous, e.g., Ammonia inc. Lime & Fert. Dust	3
Pesticides	Pesticide Gain	3	Pesticide Residue	3	Drift	1
Salts	Salinity	NA	Salt Concentration	NA	Dust-Salt Fraction	NA
Other	Other		Other		Other	

II. Rank of Environmental Effects among Media

Rank Order	Medium	Effect
1	Soil	Soil Loss
2	Water	Nutrient Gain
3	Water	Sediment Gain
4	Air	Drift
5	Water	Pesticide Gain

III. Rank of Each Medium's Aggregate Environmental Effects

Rank Order	Medium	Index
1	Water	100
2	Soil	98
3	Air	20

1/ The general terms shown are used hereafter to represent all environmental media effects and pollutant concerns.

concern. Although the soil medium was considered of greatest current concern in only the Great Plains region, it was of near equal concern with water in the Southeastern region. By 2010, the soil medium was projected to assume greater relative concern nationally than it presently does.

A discussion of the panels' findings is presented for each of the three assessment procedure steps in parts B to D; a summary of environmental effects by region is presented in part E.

B. Step 1: Pollutant Rankings Within Each Medium

Each regional panel assessed the effects on water, air, and soil of five pollutant categories--Sediments, Nutrients, Pesticides, Salts, and Others. Their specific effects within each medium were categorized as follows:

Type of Pollutant	Water Effect	Soil Effect	Air Effect
Sediment	Sediment gain	Soil loss	Dust/Particulates
Nutrients	Nutrient gain	Nutrient loss	Gaseous
Pesticides	Pesticide gain	Pesticide loss	Drift
Salts	Salinity	Salt concentration	Dust-salt fraction only
Other	BOD/Pathogens	Heavy Metals	Odor

The individual medium effects, as shown above, were separately assessed and ranked for the current and the projected periods. (For the trend analysis portion of the study, Section VI, only the aggregate effects of each type of pollutant were assessed.)

A composite summary of each regional panel's assessment of its crop production subsector's environmental effects is shown in Exhibit V-2 for the current period and in the 2010 period, for both the moderate and high growth cases. The changes in the detailed pollutant effects' rankings by environmental media from the current period to 2010 are indicators of potentially significant relative changes in the crop production subsector's effects on the regional environments. Such changes in rankings are the expected result of trend developments within the respective regional crop production subsectors. These rankings (index ratings were not obtained) do not indicate, however, the degree of change in each medium's aggregate environmental quality. Later, (Section VI), the panels' estimates of the aggregate change in the environment by type of pollutant, sediment, nutrients, pesticides, and salts are presented relative to the current period.

In the Northeastern region, as indicated in Exhibit V-2, nutrient gain was the primary water medium concern, followed by sediment gain. Future BOD/pathogen water effects are expected to increase in importance (from rank 4 to rank 3) because of anticipated greater land applications of animal and

Exhibit V-2. Rank of environmental concern by medium.

	Northeastern			Southeastern			Cornbelt/Lake			Great Plains			Western		
	C	M	H1/	C	M	H	C	M	H	C	M	H	C	M	H
Water															
Sediment gain	2	2	2	2	2	1	1	1	1	1	1	1	1	2	2
Nutrient gain	1	1	1	1	1	2	2	2	2	2	2	2	3	3	3
Pesticide gain	3	4	4	3	3	3	3	3	3	3	3	3	4	4	4
Salinity	-	-	-	-	-	-	-	-	-	4	4	4	2	1	1
BOD-Pathogens	4	3	3	-	-	-	-	-	-	-	-	-	-	-	-
Soil															
Soil loss	1	1	1	1	1	1	1	1	1	1	1	1	3	2	2
Nutrient loss	2	3	3	2	2	2	2	2	2	2	2	2	2	3	3
Pesticide residue	3	4	4	3	3	3	3	3	3	4	4	4	4	5	5
Salt concentration	-	-	-	-	-	-	-	-	-	3	3	3	1	1	1
Heavy metal concentration	4	2	2	-	-	-	-	-	-	-	-	-	5	4	4
Air															
Dust/Particulates	-	3	3	2	2	2	1	1	1	1	1	1	1	1	1
Gaseous	close⟨ 1	1	1	3	3	3	3	3	3	3	3	3	4	3	3
Drift (pesticide)	2	2	2	1	1	1	2	2	2	2	2	2	2	2	2
Dust salt fraction	-	-	-	-	-	-	-	-	-	4	4	4	5	4	4
Smoke	-	-	-	-	-	-	-	-	-	-	-	-	3	5	5

1/ Tabulated from Forms 1, 6 and 9

2/ C denotes current period
M denotes moderate growth in 2010
H denotes high growth in 2010

municipal wastes. Also the expected increase in municipal (including industrial) waste disposal on cropland will increase the heavy metal concentrations in the soil medium, and under both moderate and high growth assumptions this pollutant's rank will shift from 4 to 2. Soil loss, however, remains the primary soil medium concern throughout the period under consideration. No changes in ranking of the two major concerns occurred within the air medium where gaseous nutrients and pesticide drift were the principal environmental effects.

In the Southeastern region, no changes occurred in the water medium rankings--(1) nutrient gains,(2) sediment gains, (3) pesticide gains--from the current period to 2010 under moderate growth assumptions. However, under the high growth scenario, sediment gain was ranked first and nutrient gain, second. No changes in rankings were made in either the soil medium--(1) soil loss, (2) nutrient loss, (3) pesticide gain or the air medium--(1) pesticide drift, (2) dust and particulates, (3) gaseous matter--pollutant concerns under either growth assumptions.

In the Cornbelt/Lake States region, the pollutant effects rankings within the three primary media remained constant under the current and projected conditions of the study as presented. The major pollutant rankings indicate that sediment gain in water, soil loss from the soil medium, and dust/particulates in air are the primary concerns in the respective media under moderate and high growth conditions.

In the Great Plains region, the rankings of pollutant effects within each environmental medium also remained constant over time under both growth scenarios. Sediment gain in water, soil loss from the soil, and dust/particulates in air were the top ranked concerns for the media. Salinity is a concern in this region. Salinity is ranked fourth in the water medium, salt accumulation is ranked third in the soil medium, and dust-salt fraction is ranked fourth in the air medium.

In the Western region, "salts" both in the soil and in the water are of paramount environmental concern now and for the projected future. In the current period, the level of sediment gain in the water medium was ranked first and salinity was ranked second. However, in the future, under either moderate or high growth conditions, these rankings change so that salinity becomes the main water medium concern. In the soil medium, salt concentration is the primary concern both now and to 2010. Over time, heavy metal accumulations in the soil were seen as increasing in importance, with a current rank of 5 and a change by 2010 to a rank of 4, as indicated. Air medium concerns were primarily dust (rank 1) and pesticide drift (rank 2) and these are unchanged over time; however nutrient-related gases are expected to increase (from rank 4 to rank 3) in importance over time, whereas smoke will decrease in importance (from rank 3 to rank 5).

C. Step 2: Rank of Environmental Effects Among Media

The second step involved ranking the effects of the top five pollutants and their associated media under current crop production conditions and under moderate and high projected growth conditions to 2010.

The major environmental pollutant concerns by media for each region, as shown in Exhibit V-3, are discussed below.

The Northeastern panel was concerned about the water and soil media. Currently, nutrient gain (rank 1), sediment gain (rank 3) and pesticide gain (rank 4) were judged the most significant water pollutants. Soil loss (rank 2) and nutrient loss (rank 5) were judged the most significant concerns in the soil medium. By 2010, the two top concerns, nutrient gain in water and soil loss from soil, remain unchanged, and sediment gain in water will rank 4. Significant changes, however, are expected under either of the two growth scenarios. In particular, heavy metals in soil (rank 3) and BOD/pathogens in water (rank 5) are anticipated because of the increased land disposal of municipal sludge.

The Southeastern panel ranked soil loss from the soil as the number one concern under present crop production conditions. Three pollutants affected the water medium--nutrient gain (rank 2), sediment gain (rank 3),and pesticide gain (rank 5). Pesticide drift (rank 4) was the only air medium concern. Under moderate growth, no change in ranking is projected to 2010. In 2010 under high growth, a shift in ranking is projected: water medium - sediment gain (rank 2) will then be ranked ahead of water medium - nutrient gain (rank 3); all other rankings will remain the same.

The Cornbelt/Lake State region concluded that three of the current top pollutants effect water: sediment gain (rank 1), nutrient gain (rank 2) and pesticide gain (rank 4). Soil loss (rank 3) is the principal current soil medium concern, and dust (rank 5) is the most important air medium concern. In 2010, soil loss increases in importance from its current rank of 3 to 2 under moderate growth, and to a rank of 1 under high growth assumptions. The generally increasing concern for soil loss (and hence, the loss of soil productivity) is caused by the expected full utilization of the Class I to III soils by 2010 under moderate growth, the consequent increase in the use of marginal land, and the more intensive crop production on all lands under the high growth case.

The Great Plains panel ranked soil and water as the two media of greatest environmental concern at the present time and in 2010. Currently the rankings in descending order are: soil loss from soil, sediment gain in water, nutrient loss from soil, nutrient gain in water,and dust in air. Under either growth scenario to 2010, the only change in rank reflects the growing concern for the soil medium, as nutrient loss from soil moves up to rank 2 from 3 and sediment gain in water drops from rank 2 to 3.

Exhibit V-3. Regional crop production subsectors' environmental effects rankings of pollutant concerns by environmental media, current and projected [1]

Environmental Medium-Pollutant Concern	Current	2010	
		Moderate	High
	I. Northeastern		
Water - Nutrient gain	1	1	1
Soil - Soil loss	2	2	2
Water - Sediment gain	3	4	4
Water - Pesticide gain	4	-	-
Soil - Nutrient loss	5	-	-
Soil - Heavy Metals	-	3	3
Water - BOD/Pathogens	-	5	5
	II. Southeastern		
Soil - Soil loss	1	1	1
Water - Nutrient gain	2	2	3
Water - Sediment gain	3	3	2
Air - Pesticide drift	4	4	4
Water - Pesticide gain	5	5	5
	III. Cornbelt/Lake States		
Water - Sediment gain	1	1	2
Water - Nutrient gain	2	3	3
Soil - Soil loss	3	2	1
Water - Pesticide gain	4	4	4
Air - Dust	5	5	5
	IV. Great Plains		
Soil - Soil loss	1	1	1
Water - Sediment gain	2	3	3
Soil - Nutrient loss	3	2	2
Water - Nutrient gain	4	4	4
Air - Dust	5	5	5
	V. Western		
Soil - Salt gain	1	1	1
Water - Sediment gain	2	3	3
Water - Salt gain	3	2	2
Soil - Nutrient loss	4	5	5
Soil - Soil loss	5	4	4

1/ Tabulated from Forms 1, 6 and 9

2/ Alternative futures to 2010, i.e., moderate growth and high growth secnarios as defined.

The Western region panel considered salt gain in the soil medium to be the primary environmental concern currently and under both growth scenarios. Two other soil related effects were ranked currently as: nutrient loss (rank 4) and soil loss (rank 5). Two main water medium current concerns were sediment gain (rank 2) and salt gain (rank 3). With growth, the salt gain in water concern is predicted to intensify, relative to sediment gain in water, and by 2010, is expected to rank second, with sediment gain in water moving to number three. Also by 2010 soil loss from soil is expected to increase to rank 4. Over the entire assessment period, however, the principal environmental concern continued to be salt gain in soil.

D. Step 3: Ranking of Aggregate Environmental Effects by Media

Finally the aggregate environmental effects of each medium were ranked and their relative environmental importance was rated on an index scale of 0-100 where 100 indicated the medium of greatest environmental concern.

Exhibit V-4 summarizes the regional panels' assessments of the environmental effects of the crop production system on the three primary media--water, soil, and air--for the current period and for both the moderate and high growth scenarios in 2010. The projected levels of the effects reflect the assumed trend changes in inputs, management practices, and residual treatments which will occur under both growth scenario assumptions. The reasons for these rankings (and ratings) vary, importantly, by region as is explained in Section V-B above. For example, while sediment, nutrient, salt and pesticide gains in the water medium are all ranked as major concerns in one or more regions, their order of importance differs among regions.

Under projected conditions to 2010, whether under moderate growth or high growth assumptions, the main environmental media rankings (and ratings) show important changes within regions. Water was the current major environmental concern in all regions except the Great Plains, but in general with growth over time, the soil medium becomes of relatively greater concern. Under moderate growth assumptions, the soil medium became the main concern (index = 100) of the Northeastern region panel and water, the second (index = 90). The soil index rating increased from 70 to 80 in the Cornbelt/Lake States under moderate growth and even further to 95 under high growth assumptions. Under moderate growth conditions, the Western region expected to realize an improvement in soil medium concerns, relative to water, with a soil rating index decrease from 90 to 75; however, under high growth, the index increased to 95 in 2010. Soil remained the medium of greatest concern in the Great Plains under both growth scenarios. In the Southeastern region under high growth assumptions, soil and water were of equal importance.

Hence, although the water medium remained the major environmental concern of the crop production subsectors in three of the five regions in 2010 under moderate growth, there was generally a relative increase in the importance of these subsectors' activities on the soil medium and its associated productivity. In fact, under high growth assumptions, the soil medium was

Exhibit V-4. Regional crop production subsectors' environmental effects ratings of environmental media current and projected 1/

Environmental Medium	Current	2010 2/ Moderate	2010 2/ High
	I. Northeastern		
Water	100 3/	90	100
Soil	65	100	100
Air	10	5	5
	II. Southeastern		
Water	100	100	100
Soil	98	99	100
Air	20	10	10
	III. Cornbelt/Lake States		
Water	100	100	100
Soil	70	80	95
Air	25	20	20
	IV. Great Plains		
Water	70	70	75
Soil	100	100	100
Air	10	10	10
	V. Western		
Water	100	100	100
Soil	90	75	95
Air	10	5	5

1/ Tabulated from Form 9.

2/ Alternative futures to 2010, i.e., moderate growth and high growth scenarios as defined.

3/ An index of 100 indicates the medium having the greatest relative environmental importance.

ranked first or tied for first in three of the five regions, and the other two regions gave soil an index rating of 95. Thus, both water and soil are of major concern in the future.

The air medium effects of the crop production subsectors' activities were consistently ranked a distant third in all regions--both currently and in the future. The index ratings ranged throughout the analysis from only 5 to 25--with some improvement, or a constant relative impact, expected in all regions. Some specific air pollutants were identified; however, in the aggregate, air medium concerns were generally minor compared to those for the water and soil media.

E. Summary of Environmental Effects by Region

The results of the three step analysis procedure are probably best depicted by the completed forms of each of the regional panels, reproduced here as Exhibits V-5 through V-9. Although no interpanel quantitative comparison would be valid as each of the five panels worked independently and their ranking scales were not identical, the qualitative assessment reveals that the environmental impacts resulting from crop production activities on water and soil media nationwide are of much greater concern than their impact on the air medium.

As shown in Exhibit V-5, the Northeastern regional panel rated the water medium as its current principal crop production environmental effect because of the associated nutrient, sediment, and pesticide gains. The soil medium was the next most impacted medium because of soil and nutrient losses which were the 2nd and 5th ranked pollutant effects across all media. Over time, and under the moderate growth scenario conditions, the soil medium environmental effects are expected to become of greater concern, particularly because heavy metal concentrations are projected to increase in the region from greater applications of municipal and industrial waste treatment sludge on cropland. Under the high growth scenario assumptions, no changes in pollutant rankings across media were forecast, although the soil medium (100) was then considered to be of concern equal to the water medium (100) while the air medium crop production environmental effects remain relatively minor (5) in comparison.

The main current-period environmental concern in the Southeastern region caused by the crop production subsector was its effects on the water medium (100), i.e., its nutrient, sediment and pesticide effects in water as shown in Exhibit V-6. However, soil loss (and its consequent effects on soil productivity) was the single most important environmental effect among all media and the soil medium (98) was of high relative concern. Under either moderate or high growth cases of this study, the soil medium is projected to increase in environmental importance, equalling the water medium by 2010 under the high growth scenario. Air medium concerns were relatively low (10) in importance in the projected futures.

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Form 9

Exhibit V-5. REGIONAL CROP PRODUCTION SUBSECTOR'S ENVIRONMENTAL CONCERNS

Region: Northeastern Time Period: 2010 Growth Scenario: High

I. Rank of Environmental Concerns by Medium

	Current Rank (from Form 1)		Moderate Growth Rank (from Form 6)	High Growth Scenario Rank
Water				
Sediment Gain	2		2	2
Nutrient Gain	1		1	1
Pesticide Gain	3		4	4
Salinity	-		-	-
Other BOD-Pathogen	4		3	3
Soil				
Soil Loss	1		1	1
Nutrient Loss	2		3	3
Pesticide Loss	3		4	4
Salt Concentration	-		-	-
Other Heavy Metal	4		2	2
Air				
Dust/Particles	☐		3	3
Gaseous; e.g., ammonia	1	Close	1	1
Drift	2		2	2
Dust-Salt Fraction	☐		☐	☐
Other ______	☐		☐	☐

II. Rank of Environmental Effects among Media

	Current		Moderate Growth		High Growth Scenario	
Rank Order	Medium	Effect	Medium	Effect	Medium	Effect
1	Water	Nutrient gain	Water	Nutrient gain	Water	Nutrient gain
2	Soil	Soil loss	Soil	Soil loss	Soil	Soil loss
3	Water	Sediment gain	Soil	Heavy metal	Soil	Heavy metal
4	Water	Pesticide gain	Water	Sediment gain	Water	Sediment gain
5	Soil	Nutrient loss	Water	BOD-Pathogen	Water	BOD-Pathogen

III. Rank of Each Medium's Aggregate Environmental Effects

	Current		Moderate Growth		High Growth Scenario	
Rank Order	Medium	Index	Medium	Index	Medium	Index
1	Water	100	Soil	100	Soil	100
2	Soil	65 (15-90)	Water	90	Water	100
3	Air	10	Air	5	Air	5

Form 9

Exhibit V-6. REGIONAL CROP PRODUCTION SUBSECTOR'S ENVIRONMENTAL CONCERNS

Region: Southeastern Time Period: 2010 Growth Scenario: High

I. Rank of Environmental Concerns by Medium

	Current Rank (from Form 1)	Moderate Growth Rank (from Form 6)	High Growth Scenario Rank
Water			
Sediment Gain	2	2	1
Nutrient Gain	1	1	2
Pesticide Gain	3	3	3
Salinity	NA	NA	NA
Other ______			
Soil			
Soil Loss	1	1	1
Nutrient Loss	2	2	2
Pesticide Loss	3	3	3
Salt Concentration	NA	NA	NA
Other ______			
Air			
Dust/Particles	2	2	2
Gaseous; e.g., ammonia	3	3	3
Drift	1	1	1
Dust-Salt Fraction	NA	NA	NA
Other ______			

II. Rank of Environmental Effects among Media

	Current		Moderate Growth		High Growth Scenario	
Rank Order	Medium	Effect	Medium	Effect	Medium	Effect
1	Soil	Soil loss	Soil	Soil loss	Soil	Soil loss
2	Water	Nutrient gain	Water	Nutrient gain 2&3	Water	Sediment gain
3	Water	Sediment gain	Water	Sediment gain tie	Water	Nutrient gain
4	Air	Drift	Air	Drift	Air	Drift
5	Water	Pesticide	Water	Pesticide gain	Water	Pesticide gain

III. Rank of Each Medium's Aggregate Environmental Effects

	Current		Moderate Growth		High Growth Scenario	
Rank Order	Medium	Index	Medium	Index	Medium	Index
1	Water	100	Water	100	Water	100
2	Soil	98	Soil	98+	Soil	100
3	Air	20	Air	10	Air	10

Form 9

Exhibit V-7. REGIONAL CROP PRODUCTION SUBSECTOR'S ENVIRONMENTAL CONCERNS

Region: Cornbelt/Lake States **Time Period:** 2010 **Growth Scenario:** High

I. Rank of Environmental Concerns by Medium

	Current Rank (from Form 1)	Moderate Growth Rank (from Form 6)	High Growth Scenario Rank
Water			
Sediment Gain	1	1	1
Nutrient Gain	2	2	2
Pesticide Gain	3	3	3
Soil			
Soil Loss	1	1	1
Nutrient Loss	2	2	2
Pesticide Loss	3	3	3
Air			
Dust/Particles	1	1	1
Gaseous; e.g., ammonia	3	3	3
Drift	2	2	2

II. Rank of Environmental Effects among Media

	Current		Moderate Growth		High Growth Scenario	
Rank Order	Medium	Effect	Medium	Effect	Medium	Effect
1	Water	Sediment gain	Water	Sediment loss	Soil	Soil loss
2	Water	Nutrient gain	Soil	Soil loss	Water	Sediment gain
3	Soil	Soil loss	Water	Nutrient gain	Water	Nutrient gain
4	Water	Pesticide loss	Water	Pesticide loss	Water	Pesticide gain
5	Air	Dust particle	Air	Dust particle	Air	Dust particle

III. Rank of Each Medium's Aggregate Environmental Effects

	Current		Moderate Growth		High Growth Scenario	
Rank Order	Medium	Index	Medium	Index	Medium	Index
1	Water	100	Water	100	Water	100
2	Soil	70	Soil	80	Soil	95
3	Air	25	Air	20	Air	20

Form 9

Exhibit V-8. REGIONAL CROP PRODUCTION SUBSECTOR'S ENVIRONMENTAL CONCERNS

Region: Great Plains   Time Period: 2010   Growth Scenario: High

I. Rank of Environmental Concerns by Medium

	Current Rank (from Form 1)	Moderate Growth Rank (from Form 6)	High Growth Scenario Rank
Water			
Sediment Gain	1	1	1
Nutrient Gain	2	2	2
Pesticide Gain	3	3	3
Salinity	4	4	4
Other ________	☐	☐	☐
Soil			
Soil Loss	1	1	1
Nutrient Loss	2	2	2
Pesticide Loss	4	4	4
Salt Concentration	3	3	3
Other ________	☐	☐	☐
Air			
Dust/Particles	1	1	1
Gaseous; e.g., ammonia	3	3	3
Drift	2	2	2
Dust-Salt Fraction	4	4	4
Other ________	☐	☐	☐

II. Rank of Environmental Effects among Media

	Current		Moderate Growth		High Growth Scenario	
Rank Order	Medium	Effect	Medium	Effect	Medium	Effect
1	Soil	Soil loss	Soil	Soil loss	Soil	Soil loss
2	Water	Sediment gain	Soil	Nutrient loss	Soil	Nutrient loss
3	Soil	Nutrient loss	Water	Sediment gain	Water	Sediment gain
4	Water	Nutrient gain	Water	Nutrient gain	Water	Nutrient gain
5	Air	Dust	Air	Dust	Air	Dust
	Soil	Salt conc.				

III. Rank of Each Medium's Aggregate Environmental Effects

	Current		Moderate Growth		High Growth Scenario	
Rank Order	Medium	Index	Medium	Index	Medium	Index
1	Soil	100	Soil	100	Soil	100
2	Water	70	Water	70	Water	75
3	Air	10	Air	10	Air	10

Form 9

Exhibit V-9. REGIONAL CROP PRODUCTION SUBSECTOR'S ENVIRONMENTAL CONCERNS

Region: Western Time Period: 2010 Growth Scenario: High

I. Rank of Environmental Concerns by Medium

	Current Rank (from Form 1)	Moderate Growth Rank (from Form 6)	High Growth Scenario Rank
Water			
Sediment Gain	1	2	2
Nutrient Gain	3	3	3
Pesticide Gain	4	4	4
Salinity	2	1	1
Other ____	-	-	
Soil			
Soil Loss	3	2	2
Nutrient Loss	2	3	3
Pesticide Loss	4	5	5
Salt Concentration	1	1	1
Other ____	5	4	4
Air			
Dust/Particles	1	1	1
Gaseous; e.g., ammonia	4	3	3
Drift	2	2	2
Dust-Salt Fraction	5	4	4
Other ____	3	5	5

II. Rank of Environmental Effects among Media

	Current		Moderate Growth		High Growth Scenario	
Rank Order	Medium	Effect	Medium	Effect	Medium	Effect
1	Soil	Salinity	Soil	Salinity	Soil	Salinity
2	Water	Sediment gain	Water	Salinity	Water	Salinity
3	Water	Salinity	Water	Sediment gain	Water	Sediment gain
4	Soil	Nutrient loss	Soil	Soil loss	Soil	Soil loss
5	Soil	Soil loss	Soil	Nutrient loss	Soil	Nutrient loss

III. Rank of Each Medium's Aggregate Environmental Effects

	Current		Moderate Growth		High Growth Scenario	
Rank Order	Medium	Index	Medium	Index	Medium	Index
1	Water	100	Water	100	Water	100
2	Soil	90	Soil	75	Land	95
3	Air	10	Air	5	Air	5

The Corn Belt/Lake States regional panel rated the water medium as the most impacted environmental media, both currently and in the projected future. Sediment, nutrient and pesticide gains contributed most to this rating as shown in Exhibit V-7. The soil medium was ranked second in overall importance, but it was also projected to become of increasing concern, primarily because of soil loss which would be the single most important pollutant effect in the high growth case. Dust particulates are the main air medium pollutant effect, although the medium as a whole is rated relatively low (20) compared to either water (100) or soil (80) in the 2010 moderate growth case.

As indicated in Exhibit V-8, the Great Plains panel rated the soil medium as their primary environmental concern because of the region's consequential soil loss and nutrient loss effects of crop production. The water medium was rated second, both presently and in the projected futures, with sediment and nutrient gains of primary concern. The sediment gain effect in the water medium is expected to become relatively less of a concern than nutrient loss from the soil medium in the future in this region as shown in step II of the exhibit. Air medium effects were judged to be generally controllable in the future, especially dust particulates, and, thus, this medium was rated low (10) relative to soil (100) and water (70) in the 2010 moderate growth case.

The Western region's primary crop production affected environmental media concern, both presently and in the future, is the water medium. Sediment and salt gains are the principal water medium pollutant effects, and the salinity effect is projected to increase in relative importance, i.e., sediment gains can be reduced in the future. Salt gains in the soil medium are the region's main single pollutant effect; the soil medium is also affected adversely because of both nutrient and soil losses associated with crop production. Projected air medium effects of crop production are generally minor (5) compared to either the water (100) or the soil (75) media effects in the 2010 moderate growth case.

The basic hypothesis of the study is supported by the findings in this portion of the analysis. First, the current labor pollutants by media indicate that important regional differences do exist. Second, the projected major pollutants, whether under moderate or high growth assumptions, are expected to differ in rank in 2010.

SECTION VI

CROP PRODUCTION TRENDS' ASSESSMENT: NATION AND REGIONS

Input, management practice, and residual control trends in crop production were evaluated under present conditions and under those of the 2010 moderate and high growth scenarios. Environmental effects of these trends were distinguished regionally for each growth scenario.

Based upon the judgments of the workshop's participants, two factors of major influence on the affected environmental media were the growth potential of a particular region and the time frame within which specified growth must be achieved. Under the moderate growth scenario, the panelists projected that the output requirements could be met and, at the same time, environmental enhancements could result from the anticipated trends in input use, management practices and residual control. The postulated increases in production for the regional high growth scenarios were between 13 and 17 percent higher than those for the moderate growth scenarios. As a result, the panelist's generally expected that the crop production subsector would substantially increase land utilization, including the use of more environmentally fragile land. In doing so, the use of needed more comprehensive crop management practices may not be adequately adopted because of uncertain economic returns.

A. National Perspective of the Crop Production Subsector

Although each of the regional panels assessed only its own region's crop production trends and their associated environmental effects, a composite analysis of the regions' findings shows major influences of the crop production subsector on national environmental concerns. This composite analysis, while based on the individual trend effects in each region, was completed on an aggregated-trends level. That is, the crop production system was first divided into three major components--inputs, management practices, and outputs. These components were further subdivided into trend groupings as follows:

Inputs
- Quantity
- Quality

Management Practices

- Multi-Season Management
- Crop Season Management
- Non-crop Season Management

Outputs

- Crops (specified in each scenario)
- Residuals Control

The sets of trends assessed in each region within this pre-specified framework are summarized in Exhibit VI-1.

A national perspective is more reaidly obtained by considering first the similarities and differences of the five regions at the major component-subcomponent levels. Thereafter, the individual trend assessments are more appropriately and accurately understood, e.g., although individual subcomponent trends may have adverse environmental impacts, other system-related individual trends may produce relatively beneficial effects. Hence, the expected net environmental implications are actually a composite of the individual trends. Still, however, the component-subcomponent aggregations are useful subtotal effects in distinguishing among the regions.

Under either the moderate or high growth scenario assumptions, several component-level statements are applicable. First, the quantities of inputs used will increase. In general, in order to meet the crop output projections for 2010, additional land, most often that which will require higher levels of environmental management, will have to be cultivated. Such marginal lands will also typically require increased rates (per unit of output) of nutrients and pesticides with consequent adverse environmental implications. Exceptions exist in two regions. The Northeastern region still has substantial acreages of good quality land (Classes I to III) in outlying areas that will be cultivated, and some poorer lands will be taken out of production. The Western region does not expect significantly more land to come into production, but the more intensive use of existing land resources may result in a slight degradation of land quality by 2010. This quality change has environmental implications similar to that of having relatively more marginal land in production.

Management practice trends are expected in all regions that will contribute to the achievment of both the environmental and crop output goals. Three groupings of these practices were defined to indicate their time-related characteristics: multi-season--those practices that affect more than a single cropping season, e.g., land development; crop season--those practices that are applied when the crop is present (including planting), e.g., pest control; and, non-crop season--those practices that are applied when the crop is not present, e.g., soil protection (see Exhibit VI-1).

In general, the regional panels determined that land development practices such as terraces and other land forming practices, crop planting practices such as no-till planting and narrow rows, and soil protection practices

Exhibit VI- 1. Summary of crop production system variables: inputs, management practices, and outputs

- I. INPUTS
  - A. Quantity
    - 1. Land (cropland acres)
    - 2. Nutrients
    - 3. Pesticides
    - 4. Water for irrigation
    - 5. Seeds and plants
    - 6. Other (e.g., equipment)
  - B. Quality
    - 1. Land
      - a) composition of acres cultivated
      - b) dryland vs. irrigated
    - 2. Nutrients
      - a) alternative sources
      - b) alternative formulations
    - 3. Pesticides
      - a) alternative formulations
      - b) biological controls
      - c) integrated controls
    - 4. Water for irrigation
      - a) groundwater
      - b) surface water
      - c) saline water
    - 5. Seeds and plants
      - a) yield potential
      - b) pest resistance
      - c) drought resistance
      - d) salt tolerance
      - e) alternative crops
- II. MANAGEMENT PRACTICES
  - A. Multi-Season Management
    - 1. Land Development Practices
      - a) terraces
      - b) waterways
      - c) land forming
      - d) irrigation structures
      - e) windbreaks
    - 2. Crop Sequence Practices
      - a) mono-crop
      - b) no-meadow rotation
      - c) sod-based rotation
      - d) double cropping
      - e) relay cropping
  - B. Crop Season Management
    - 1. Crop Planting Practices
      - a) no-till planting
      - b) narrow row planting
      - c) contour planting
      - d) strip-cropping (and barrier row)
    - 2. Crop and Field Monitoring Practices
      - a) surface scouting
      - b) remote-sensing scouting
      - c) soil-plant analysis
- II. MANAGEMENT PRACTICES (continued)
    - 3. Crop Fertilization Practices
      - a) surface applied
      - b) aerial applied
      - c) foliar applied
      - d) multiple applications
    - 4. Pest Control Practices
      - a) surface applied - spray and broadcast
      - b) surface applied - banded
      - c) aerial applied
      - d) simultaneous fertilizer/pesticide applied
      - e) integrated pest control
    - 5. Water Application Practices
      - a) furrow basins (and borders)
      - b) sprinklers
      - c) water conserving (trickle, other)
      - d) recycling tailwater
  - C. Non-crop Season Management
    - 1. Crop Residue Control Practices
      - a) fall incorporation
      - b) spring incorporation
      - c) residue removal
      - d) residue burning
    - 2. Soil Protection Practices
      - a) reduced tillage
      - b) cover crops
      - c) contour tillage
      - d) chemical erosion control
    - 3. Moisture Control Practices
      - a) fallow cropping
      - b) chemical tillage
      - c) chemical evapotranspiration control
    - 4. Pre-plant Fertilization Practices
      - a) fall applied
      - b) seed-bed applied
    - 5. Pre-plant Pest Control Practices
      - a) non-crop season
      - b) pre-emergent
- III. OUTPUTS
  - A. Crops (as specified)
  - B. Residuals Control
    - 1. Pollutant Treatment
      - a) barrier strips
      - b) retention ponds
      - c) diversion dikes
      - d) chemical/mechanical
    - 2. Other Treatments
      - a) land-use restrictions
      - b) cropping restrictions

such as reduced tillage and cover crops had favorable environment impacts--moderate to major effects on sediments, and minor to moderate impacts on nutrients and pesticides. However, in the Cornbelt/Lake States and Western regions, crop planting practices had a minor adverse environmental effect on pesticide levels.

In most regions, the projected crop sequencing practices, e.g., monocropping, and the projected crop residue control practices are expected to have minor adverse environmental effects, i.e., sediment, nutrient, and pesticide effects. However, in all regions these adverse implications are more than offset by the counter balancing beneficial implications of other improved management practices.

Irrigated crop production is expected to increase throughout the nation, especially so, relatively, in the Cornbelt/Lake States and the Southeastern regions. This general trend will have adverse environmental direct impacts--particularly on nutrient and pesticide losses in the Cornbelt/Lake States, and on soil and pesticide losses in the Southeastern regions. The other three regions do not anticipate significantly changed environmental effects from their trends in irrigation.

Regarding residual outputs, the regional panels did not expect residual control practices to be used substantially by 2010. Although prospective residual treatment methods, e.g., barrier strips and retention ponds, and land use restrictions, e.g., zoning, were recognized as potentially beneficial to the environment, it was believed that these practices would not be widely adopted voluntarily; publically supported programs would generally be necessary to achieve these types of residual control (preferably preventive practices vs. "treatment" alternatives would accomplish environmental objectives while also meeting crop output goals).

1. Aggregate Environmental Effects Ratings--Moderate Growth Scenario

The composite effects of all input, management practice, and residual control trends were assessed for the four principal pollutant concerns of the crop production subsector: sediment, nutrients, pesticides, and salt. (All primary media--water, soil, and air--effects were included in the assessment.) The assessment procedure, as explained in Appendix A, required that a series of rating aggregations be made from individual trends to related trend-groups (see Exhibits VI-3 to VI-7, below) and then across all major components of the crop production system. This assessment procedure was repeated for each of the study's specified growth scenarios to 2010; thus, comparative results were obtained for expected changes from 1977 to 2010 in relative terms as explained further below.

Under the moderate growth scenario, all regional panels projected improved environmental effects in 2010 compared to the current (1977) situation when the aggregate environmental effects of the anitcipated changes in the crop production system's inputs, management practices and residual controls were evaluated. On a scale of 1 = minor to 5 = major (and where + denotes beneficial and - adverse) 1/, each of the five regions predicted either positive changes or no changes in sediment, nutrient, pesticide, salts and other environmental concerns as indicated in Exhibit VI-2. These environmental improvements were judgmentally derived as a result of all projected qualitative and quantitative trend changes in the use of inputs, management practices, and residual treatments.

The Northeastern region anticipates that minor improvements will be achieved in sediment control (+1) and pesticide control (+1) but that no effective change will occur in its nutrient effects resulting from crop production activities. The Southeastern region expected to achieve some improvement in both sediment (+2) and pesticide residual control (+2), and achieve minor improvement in nutrient (+1) environmental effects.

The Cornbelt/Lake States region projects major improvements in sediment (+5) control to 2010 under moderate growth and some improvement in both environmental effects of nutrients (+2) and pesticides (+2). The Great Plains region expects to achieve moderate improvements in its crop production subsector's sediment (+3) and nutrient effects, while achieving substantial improvements in its pesticide (+4) environmental effects.

Under moderate growth assumptions, the Western region's crop production subsector is expected to show environmental effect improvements in sediment (+3), nutrients (+2), pesticides (+2) and salts (+1) by 2010.

A generally recognized problem with this type of rating procedure, where the current situation is rated as "0" for each effect, is that even a relatively moderate improvement, e.g., "+3", in one effect may still represent an environmental management concern. That is, the absolute levels of pollutants in the environment are known in neither the current ("0") nor the future ("+3") rated situations. This condition was recognized in the study procedures, but no definitive data base is available to adequately characterize, regionally, the current environmental status. Only relative, subjectively determined ratings were, therefore, possible in this analysis.

2. Aggregate Environmental Effects Ratings--High Growth Scenario

As is also shown in Exhibit VI-2, the regional panels estimated relative 1977 to 2010 changes in sediment, nutrient, pesticide and salt (and other) environmental effects resulting from all trends in inputs, management practices and residual controls under the high growth scenario assumptions. These ratings are directly comparable to those of the moderate growth case since the study procedures were replicated for the high vs. the moderate growth assumptions (see Appendix A).

1/ The rating scale is described, in part, as follows: 1 = minor, 2 = some, 3 = moderate, 4 = substantial, and 5 = major. Actual ratings are as presented in the following exhibits and in Appendix B.

Exhibit VI-2. Estimated changes in the environment by region under alternative growth assumptions 1/

Region/Scenario	Sediment	Nutrient	Pesticide	Salts/ Other
Northeastern				
Moderate Growth	+1 2/	0	+1	NA
High Growth	+1	0	+1	NA
Southeastern				
Moderate Growth	+2	+1	+2	NA
High Growth	+1	+1	+1	NA
Cornbelt/Lake States				
Moderate Growth	+5	+2	+2	NA
High Growth	+2	-2	-1	NA
Great Plains				
Moderate Growth	+3.1	+3.4	+3.9	+.6
High Growth	+2.8	+2.9	+3.7	+.4
Western				
Moderate Growth	+3	+2	+2	+1
High Growth	+2	+1	+1	-1

1/ Tabulated from Forms 5 and 8.

2/ Scale: 1 (minor) to 5 (major)
+ denotes beneficial
- denotes adverse
NA - not assessed

Assuming the high growth scenario to 2010, the regional panels were less optimistic that the projected improvements in inputs, management practices, and residual controls would offset increased environmental consequences of the crop production system. However, in all but two regions, the aggregate environmental effect ratings were still equal to or better than current environmental conditions, though they were most often less than the moderate growth case.

Both the Cornbelt/Lake States and the Western regions projected that certain environmental effects would worsen from their current status by 2010 under high growth assumptions. In particular, the Cornbelt/Lake States panel anticipated that its region's nutrient (-2) and pesticide (-1) effects would become more problematic. The Western panel projected minor adverse salt-related (-1) environmental effects compared to either the current (0) or the 2010 moderate growth (+1) salt-related conditions. The other environmental effects, e.g., sediment, in these regions were less favorable, but still positive under high growth as compared to current effects.

The Southeastern panel predicted slightly less favorable environmental changes in the sediment (+1) and pesticide (+1) effects at the high growth rate when compared to +2 ratings for the same effects at the moderate growth level. The nutrient environmental effect remained the same for both growth scenarios for this region. Under high growth assumptions, both the Northeastern and Great Plains regions remained at the same effect levels as those predicted at the moderate growth level with one exception--salts and other environmental effects dropped from +1 to 0 in the Great Plains region. (As shown in Exhibit VI-2, the Great Plains panel did show very minor less-favorable effects using unrounded rating scores.)

These aggregate ratings of expected environmental effects for sediment, nutrients, pesticides, and salt--in all media--were derived by the panels by utilizing Forms 5 and 8, Appendix A. Further, Forms 2, 3 and 4 provided requisite trend evaluation inputs--see Appendix B. Next, a summary of major trend assessment results, by region, is presented. Such findings both preceded and were critical to the systematic development of the aggregate ratings shown in this section.

B. Northeastern Crop Production Trends: Moderate Growth Scenario 1/

The aggregate environmental effect from the crop production subsector activities in 2010, though not substantially differing from the current effects in the Northeastern Region will result in a minor improvement in sediment and pesticide loss and no overall change in nutrients. Although no appreciable change in these concerns is expected, new environmental concerns are predicted to emerge, e.g., the recent interest in the application of municipal wastes to cropland will probably create an accumulation of heavy metals in the soil and a biological oxygen demand/pathogenic problem in Northeastern streams and lakes.

1. Inputs

Environmentally important input use trends in the Northeastern region are the projected increases in land use, nutrient use, and improved seeds and plants (Exhibit VI-3). Additional and replacement land use will bring higher grades of land into production that will lessen the relative nutrient and pesticide effects. Previously, land of poorer quality (Class IV - VIII) that is closer to urban markets was utilized for crop production even though higher quality land (Class I - III) is available in outlying areas of the region. Crop producers have now started to shift production to the better land which is less subject to runoff and erosion problems. The Census of Agriculture confirms this potential, i.e., in 1974, 16.1 million acres were in cropland while 39.8 million acres of Class I - III land were available in the region.

1/ The detailed trend assessments of each trend's extensiveness of use and intensiveness of environmental effects is presented, for all regions, in Appendix B: Regional Data and Trend Definitions.

Exhibit VI-3. Environmental implications of trends in regional crop production activities by type of pollutant under alternative growth scenarios, present to 2010, Northeastern region (Region I)

Crop Production Variable	Moderate Growth			High Growth			Change [1]		
	Sediments	Nutrients	Pesticides	Sediments	Nutrients	Pesticides	Sediments	Nutrients	Pesticides
	Rating of composite environmental effects [2]								
INPUTS									
A. Quantity Utilized									
1. Land	1	1	1	0	0	1	-1	-1	0
2. Nutrients	1	-1	0	1	-2	0	0	-1	0
3. Pesticides	0	0	-1	0	0	-1	0	0	0
4. Water for irrigation	0	0	0	0	0	0	0	0	0
5. Seeds and plants	0	0	1	0	0	1	0	0	0
6. Other (e.g. equipment)	0	0	0	0	0	0	0	0	0
B. Quality									
1. Land	1	0	0	0	0	0	-1	0	0
2. Nutrients	1	0	0	0	0	0	-1	0	0
3. Pesticides	0	0	1	0	0	1	0	0	0
4. Water for irrigation	0	0	0	0	0	0	0	0	0
5. Seeds and plants	0	1	1	0	1	1	0	0	0
6. Other	0	0	0	0	0	0	0	0	0
MANAGEMENT PRACTICES									
A. Multi-season management									
1. Land development	2	1	1	2	1	1	0	0	0
2. Crop sequencing	-1	-1	-1	-2	-1	-1	-1	0	0
B. Crop-season management									
1. Crop planting practices	3	0	0.5	3	0	0.5	0	0	0
2. Crop and field monitoring	0	2	2	0	2	2	0	0	0
3. Crop fertilization practices	0	0	0	0	1	0	0	1	0
4. Pest control practices	0	0	2	0	0	2	0	0	0
5. Water application practices	0	0	0	0	0	0	0	0	0
C. Non-crop season management									
1. Crop residue control practices	-1	-1	0	-1	-1	0	0	0	0
2. Soil protection practices	3	0.5	0	3	1	0	0	0.5	0
3. Moisture control practices	0	0	0	0	0	0	0	0	0
4. Pre-plant fertilizer practices	0	-0.5	0	0	0	0	0	0.5	0
5. Pre-plant pest control practices	0	0	-1	0	0	-1	0	0	0
OUTPUTS-RESIDUALS									
A. Residuals control									
1. Pollutant treatments	1	0.5	0.5	1	0	0	0	-0.5	-0.5
2. Other treatments	1	0.5	0.5	1	0	0	0	-0.5	-0.5
AGGREGATE ENVIRONMENTAL CHANGES [3]	1	0	1	1	0	1	0	0	0

[1] Change in difference between the high growth ratings and the moderate growth ratings.

[2] Region's workshop panel rating of each activity's composite primary media (water, soil, air) environmental effects in 2010 relative to the present period (scale = 0), by type of pollutant, and for alternative (moderate and high) growth scenario. Ratings range from +(beneficial) or -(adverse) (1 to 5) where 1 = minor and 5 = major.

[3] Aggregate environmental changes are the estimated total effects changes by type of pollutant for each growth scenario. Rating scale is also from ± (1 to 5) but it is applied to the aggregate effects.

Tabulated from Forms 5 and 8

Increased nutrient use will have a minor beneficial sediment effect, but a minor adverse nutrient effect on streams and lakes. The sediment or soil loss improvement will result from the nutrient-stimulation of plant growth to protect and hold the soil, whereas the projected increase in nutrient use will result in minor increases in nutrient gains in the water medium.

Both an increased use and an improved quality of seeds and plants are expected in the Northeastern region. These trends will include improvements in the yield potential and in more pest resistant crops. Increased yields and the anticipated shift from corn to soybeans will reduce nutrient concerns and will partially offset the adverse effects of increased nutrient use. Pesticide trends are predicted to be environmentally beneficial because anticipated pest-resistant crops are expected to require fewer pesticide applications and/or lower rates per application.

2. Management Practices

Management practices are expected to be more important in their environmental impacts than are changes in input trends. The minor improvement in sediment loss will be affected most by crop planting practices, soil protection practices, and land development activities, and pesticide improvements will occur mostly through crop and field monitoring practices.

Minor to moderate improvements in sediment concerns were projected to result from improved crop planting practices such as no-till and narrow row planting, and from soil protection practices such as reduced tillage and cover crops that are expected to be utilized to a greater extent. Where used, no-till practices, reduced tillage, and cover crops reduce sediment effects substantially and narrow row planting, compared to conventional row widths, reduces sediment effects to a minor extent. Their combined sediment effects were estimated to produce a moderate, positive shift from the current levels under moderate growth assumptions.

Land development practices such as terraces and grass waterways that have a moderate effect on sediment are expected to be utilized only to a minor extent and, therefore, such practices will beneficially affect sediment to a lesser degree.

The pesticide effects of crop production are predicted to show minor improvement in the Northeastern region during the next 30 years. The major beneficial trends which result in pesticide improvement are crop and field monitoring and pest control practices. Producers are expected to increase their surveillance of fields (surface scouting) and to utilize integrated pest controls. Both practices, though they are currently not extensively utilized, will be utilized moderately by 2010. These approaches will lessen the widespread use of preventive pesticides and will foster the tailoring of pesticide controls to specific problems when they occur. Moderating the overall impact of these beneficial trends are crop sequencing and pre-plant pest control practices that result in greater pesticide use.

Nutrient trends are expected to be improved most by soil-plant analysis--a crop and field monitoring technique which is currently used at a moderate level and will gradually increase in use to a substantial level. Two generally adverse management practice trend groupings in the region are its crop sequencing and crop residue control practices that will produce negative sediment, nutrient and pesticide effects. However, such adverse effects are expected to be more than counter balanced by the beneficial effects of other trends and, therefore, result in minor beneficial (or no change) aggregate environmental effects under the moderate growth scenario.

3. Residual Controls

Regulated or voluntary practices such as barrier strips, diversion dikes, and land-use restrictions could offer the Northeastern region major beneficial environmental effects. However, the projected minor utilization of such practices results in a minimal expected reduction of sediment, nutrient, or pesticide effects by 2010.

C. Southeastern Crop Production Trends: Moderate Growth Scenario

The overall environmental effects of crop production activities in the Southeastern region are predicted by the regional panel to improve in 2010 in the moderate growth case. Some improvement in sediment and pesticide concerns and a minor improvement in nutrient concerns are anticipated. Environmental enhancement was expected in spite of increased production and associated input uses. The primary concerns in the Southeastern region will continue to be soil loss from the soil medium and nutrient gains in the water medium. Input use in this region was expected to increase substantially under moderate growth; thus land, nutrients and pesticides will adversely impact the environment if no adjustments in input quality, management practices, or residual controls are made. However, sufficient changes are projected in all the components of the Southeastern crop production system such that a net improvement in the environment will result, as shown in Exhibit VI-4.

1. Inputs

Important input use changes in the crop production subsector are expected under the moderate growth scenario. The increased use of land, nutrients, pesticides and water for irrigation were recognized as causing adverse environmental changes. The adverse effects caused by increased land use reflects the increased acreages of land requiring higher levels of management. The effects of increased uses of nutrients and pesticides, however, are expected to be partially offset by improvements in the quality of agricultural chemicals (such as improved slow release formulations and a shift from inorganic to organic nutrients) and by the development of effective environmentally compatible pesticides. Increased irrigation with its attendant erosion is anticipated to increase sediment and pesticide concerns.

The increased use of quality-improved seeds and plants is projected to have beneficial effects on sediment, nutrients and pesticides since the varieties utilized are projected to be higher yielding and pest and drought resistant. As a result of the offsetting effects of use levels and quality changes, the aggregate environmental impact of input changes (only) in the Southeastern region is projected to be slightly adverse on sediments, nutrients, and pesticides.

Exhibit VI-4. Environmental implications of trends in regional crop production activities by type of pollutant under alternative growth scenarios, present to 2010, Southeastern Region (Region II)

Crop Production Variable	Moderate Growth			High Growth			Change [1]		
	Sediments	Nutrients	Pesticides	Sediments	Nutrients	Pesticides	Sediments	Nutrients	Pesticides
	Rating of composite environmental effects [2]								
INPUTS									
A. Quantity utilized [3]	-2	-2	-1	-2	-3	-2	0	-1	-1
1. Land [4]									
2. Nutrients									
3. Pesticides									
4. Water for irrigation									
5. Seeds and plants									
6. Other (e.g., equipment)									
B. Quality	-1	1	1	-1	0	1	0	-1	0
1. Land									
2. Nutrients									
3. Pesticides									
4. Water for irrigation									
5. Seeds and plants									
6. Other									
MANAGEMENT PRACTICES									
A. Multi-season management	2	1	1	1	1	1	-1	0	0
1. Land development									
2. Crop sequencing									
B. Crop-season management	1	1	1	1	1	2	0	0	1
1. Crop planting practices									
2. Crop and field monitoring									
3. Crop fertilization practices									
4. Pest control practices									
5. Water application practices									
C. Non-crop season management	1	-1	-1	1	1	-1	0	2	0
1. Crop residue control practices									
2. Soil protection practices									
3. Moisture control practices									
4. Pre-plant fertilizer practices									
5. Pre-plant pest control practices									
OUTPUTS-RESIDUALS									
A. Residuals control	1	1	1	1	1	0	0	0	-1
1. Pollutant treatments									
2. Other treatments									
AGGREGATE ENVIRONMENTAL CHANGES [5]	2	1	2	1	1	1	-1	0	-1

[1] Change in difference between the high growth ratings and the moderate growth ratings.

[2] Region's workshop panel rating of each activity's composite primary media (water, soil, air) environmental effects in 2010 relative to the present period (scale = 0), by type of pollutant, and for alternative (moderate and high) growth scenario. Ratings range from +(beneficial) or -(adverse) (1 to 5) where 1 = minor and 5 = major.

[3] Trend category ratings only were estimated by the Southeastern panel.

[4] The type of pollutant effects for individual trends were not reported, although their individual extensiveness of use and intensiveness of effect ratings are presented in Exhibit B-2 (Appendix B). Hence, the general importance of each trend is documented.

[5] Aggregate environmental changes are the estimated total effects changes by type of pollutant for each growth scenario. Rating scale is also from ± (1 to 5) but it is applied to the aggregate effects.

Tabulated from Forms 5 and 8.

2. Management Practices

Management practices were divided into multi-season, crop season and non-crop season practices. The multi-season and crop season practices are predicted to be environmentally beneficial; non-crop season practices tend to have slightly adverse nutrient and pesticide effects on the environment.

The crop season management practices involving crop planting and crop and field monitoring are expected to be more environmentally beneficial. No-till planting and the use of narrow rows are predicted to be more extensively used than at present and to be more beneficial to sediment control than to nutrient and pesticide control (see Appendix B). The use of crop and field monitoring practices, including surface scouting and soil and plant analysis, are predicted to increase, resulting in beneficial pesticide and nutrient effects.

Multi-season management practices should improve sediment and nutrient effects in the Southeastern region. Terraces, grass waterways, and land forming were identified as having moderate environmental effects where applied. However, drainage practices that are expected to develop with increased irrigation would increase sediment, nutrient, and pesticide runoff. Crop sequencing practices can be divided into those with positive or negative environmental effects. Mono-cropping and no-meadow rotation have negative effects, and the latter is currently used substantially in the Southeastern region and is not expected to decrease in the next 30 years. Relatively beneficial environmental effects result from double cropping, a trend which decreases sediment, nutrient, and pesticide problems on a per unit of output basis; however, other management practices are essential for reducing absolute pollutant effects.

Non-crop season management practices applicable to the Southeastern region are crop residue control practices, soil protection practices, and preplant fertilization and pest control practices. Of these, only soil protection methods, which include reduced tillage, cover crops, and contour tillage, are expected to beneficially affect the sediment and nutrient concerns. Reduced tillage was expected to increase from moderate to major use levels; contour tillage was not predicted to change from its current level of use.

3. Residual Controls

Residual control treatments are expected to have a beneficial effect on the environment. These treatments are about equally as beneficial as are multi-season crop practices. All of the residual control treatments are utilized to a minor degree currently and are anticipated to increase by 2010. The most beneficial treatments identified, if utilized extensively, would be land-use restrictions, retention ponds, and cropping practices. Because of the expected low utilization, however, residual controls will have only a slight positive environmental effect.

D. Cornbelt/Lake States Crop Production Trends: Moderate Growth Scenario

The aggregate environmental effects of crop production in the Cornbelt/Lake States region are expected to be beneficial under moderate growth assumptions. Sediment environmental effects are predicted to improve to a major degree; nutrient and pesticide effects to a moderate degree (Exhibit VI-5). Quantities of inputs--land, nutrients, and pesticides--will be increased; however, the availability of land may be limited as early as 1985. Changes in the form or quality of nutrients, pesticides, and seeds and plants are anticipated to modify the effect of increased input use. Management practices will make the most important contribution to environmental enhancement, but residual control practices, such as land use restrictions will also affect pollution levels, particularly the region's sediment effects.

Exhibit VI-5. Environmental implications of trends in regional crop production activities by type of pollutant under alternative growth scenarios, present to 2010, Cornbelt/Lake States (Region III)

Crop Production Variable	Moderate Growth			High Growth			Change 1/		
	Sediments	Nutrients	Pesticides	Sediments	Nutrients	Pesticides	Sediments	Nutrients	Pesticides
	Rating of composite environmental effects 2/								
INPUTS									
A. Quantity utilized									
1. Land	-4	-3	-2	-5	-4	-3	-1	-1	-1
2. Nutrients	1	-3	0	1	-5	0	0	-2	0
3. Pesticides	0	0	-3	0	0	-5	0	0	-2
4. Water for irrigation	0	-3	-1	0	-3	-1	0	0	0
5. Seeds and plants	-	-	-	-	-	-	-	-	-
6. Other (e.g., equipment)	3	2	1	2	1	0	-1	-1	-1
B. Quality									
1. Land	-2	-2	-2	-3	-3	-3	-1	-1	-1
2. Nutrients	1	3	0	1	3	0	0	0	0
3. Pesticides	0	0	5	0	0	4	0	0	-1
4. Water for irrigation	0	-3	-1	0	-4	-1	0	-1	0
5. Seeds and plants	3	4	4	3	3	3	0	-1	-1
6. Other	-	-	-	-	-	-	-	-	-
MANAGEMENT PRACTICES									
A. Multi-season management									
1. Land development	5	3	3	4	3	3	-1	0	0
2. Crop sequencing	-2	-1	-2	-3	-2	-3	-1	-1	-1
B. Crop-season management									
1. Crop planting practices	5	3	-1	3	1	0	-2	-2	1
2. Crop and field monitoring	2	4	5	2	4	5	0	0	0
3. Crop fertilization practices	0	1	0	0	1	0	0	0	0
4. Pest control practices	0	-1	-1	0	-1	-2	0	0	-1
5. Water application practices	0	-1	-1	0	-1	-1	0	0	0
C. Non-crop season management									
1. Crop residues control practices	-4	-2	0	-4	-2	0	0	0	0
2. Soil protection practices	5	3	-1	4	2	0	-1	-1	1
3. Moisture control practices	0	0	0	0	0	0	0	0	0
4. Pre-plant fertilizer practices	0	-3	0	0	-4	0	0	-1	0
5. Pre-plant pest control practices	0	0	-1	0	0	-1	0	0	0
OUTPUTS-RESIDUALS									
A. Residuals control									
1. Pollutant treatments	4	2	2	3	1	1	-1	-1	-1
2. Other treatments	4	2	2	2	1	1	-2	-1	-1
AGGREGATE ENVIRONMENTAL CHANGES 3/	5	2	2	+2	-2	-1	-3	-4	-3

1/ Change in difference between the high growth ratings and the moderate growth ratings.

2/ Region's workshop panel rating of each activity's composite primary media (water, soil, air) environmental effects in 2010 relative to the present period (scale = 0), by type of pollutant, and for alternative (moderate and high) growth scenario. Ratings range from +(beneficial) or -(adverse) (1 to 5) where 1 = minor and 5 = major.

3/ Aggregate environmental changes are the estimated total effects changes by type of pollutant for each growth scenario. Rating scale is also from ± (1 to 5) but it is applied to the aggregate effects.
Tabulated from Forms 5 and 8.

1. Inputs

In the Cornbelt/Lake States region, major and increased quantities of land, nutrients, and pesticides will be used in the crop production subsector by 2010. Use of these inputs at higher levels is expected to be environmentally degrading, i.e., substantial additional land use will increase the region's sediment, nutrient, and pesticide effects. Increased nutrient use will also cause increased nutrient concerns and additional pesticide use will heighten pesticide concerns.

The environmentally adverse effects of the increased quantities of inputs are expected to be partially offset by beneficial input quality changes. Increased sediment effects due to increased land use will be nearly offset if satisfactory production equipment and improved seeds and plants are used. Crop varieties with increased yields and drought resistance would directly and indirectly reduce sediment effects. Changes in nutrients--increased use of sludge, manure, and formulations with retarded chemical release--are expected to partially offset the adverse impact of increased nutrient use. In addition, the selection of environmentally preferred pesticide chemicals is anticipated to essentially offset aggregate increases in pesticide usage.

2. Management Practices

The importance of year-round management practices for sediment control was emphasized by this regional panel. One practice from each group of practices (see Appendix B) was selected as having a major beneficial effect on sediment. Land development as a multi-season practice was expected to result in major beneficial sediment effects and moderate beneficial effects on nutrients and pesticides. The proper selection of crop planting practices will result in a major sediment improvement and a minor adverse pesticide, i.e., no-till planting typically requires more pesticide use, effect. Soil protection practices would enhance sediment effects during the non-crop season.

Beneficial land development practices were identified primarily as the use of terraces and grass waterways. The latter will be widely used by 2010, but terraces, which are more beneficial individually, will be utilized only moderately. Subsurface drainage will be used extensively and will reduce sediment effects, but it will result in minor increases in nutrient losses. Land forming will be substantially practiced and it is expected to have minor adverse effects on sediment, nutrients, and pesticides in the environment.

No-till planting was the major beneficial crop planting practice identified. Although no-till planting substantially decreases sediment effects, it also requires the additional use of pesticides. This practice would have a moderate use level by 2010. Strip cropping was expected to be nearly as beneficial for reducing sediment effects as no-till planting, but it will be used on only a minor and decreasing proportion of the crop acres. Narrow

row planting is expected to increase in use from a moderate to a major level. This practice, however, will have only slight positive environmental effects in this region.

The use of such non-crop season practices as reduced tillage, contour tillage, and cover crops will increase. Reduced or conservation tillage is predicted to increase from its current use level to become a major crop production technique by 2010. Contour tillage will increase almost as much. Both of these tillage practices will provide moderate levels of sediment improvement. Use of cover crops, although considered to be essentially as effective environmentally as contour tillage, will increase in extent of use by only a minor amount, and thus, its overall environmental effect will be minor.

Crop and field monitoring practices are expected to moderately improve the nutrient effects and offer major improvements for pesticide concerns. The crop and field monitoring practices reviewed by the regional panelists are surface scouting, remote-sensing, soil-plant analysis, and environmental monitoring. Soil-plant analysis, predicted to be an important monitoring practice, would increase from the current moderate-use level to a major use level and would primarily affect nutrient losses as nutrients would be applied at the optimum time for maximum uptake by the plants. Environmental monitoring, e.g., soil moisture, and remote sensing, e.g., diseases, pests, and soil moisture stress, are expected to be used extensively to improve the timing and/or rates of application of management practices, and, consequently, sediment, nutrient, and pesticide effects are expected to improve. Surface scouting will be used at a moderate level and will primarily affect pesticide usage and, thus, reduce its environmental impact.

3. Residual Controls

Residual controls are most effective in reducing sediment concerns; however, the extent of use of these controls will depend upon legislation and public funds. Land-use restrictions of environmentally fragile soils are expected to be moderately used by 2010 and would be primarily important in sediment control. Diversion dikes, retention ponds, and chemical/mechanical treatment are residual control practices available to the crop production subsector; however, these three controls were considered of less importance than barrier strips or crop restriction. Overall residual controls are expected to substantially improve sediment effects and to improve somewhat nutrient and pesticide effects in the Cornbelt/Lake States region.

E. Great Plains Crop Production Trends: Moderate Growth Scenario

Enhanced environmental effects from crop production is predicted in the Great Plains region during the next 30 years under the moderate growth scenario. A moderate level of improvement is expected for aggregate sediment and nutrient concerns and a substantial improvement is anticipated in pesticide concerns (Exhibit VI-6). These favorable aggregate effects are not expected to change the major environmental concerns of the region's crop production subsector, however. Soil and nutrient losses (and, thus, also, the sediment and nutrient gains in water) are still predicted to be the dominant concerns in the Great Plains region to 2010.

1. Inputs

Increased land use by the Great Plains crop production subsector is expected to adversely affect the environment through added sediment, nutrient, and pesticide losses. The quantity of additional land utilized for cropland will be relatively minor, however, and only moderate adverse impacts are expected. Other input changes in use or form are expected to affect the environment only slightly. New pesticide formulations and biological controls are predicted by 2010, which will result in a limited level of enhancement. With expected improved seeds and plants, a moderate degree of imporvement in the pesticide concern will result.

2. Management Practices

The major environmental improvements resulting from management practice trends by 2010 are projected to result from land developments (a multi-season practice), and from crop planting and crop and field monitoring (crop-season practices).

Sediment effects are anticipated to be reduced substantially by these management practices, and moderately by non-crop season management practices, e.g., soil protection. Land development such as terraces and grass waterways are considered to be extremely effective, but the extent of their use will reach only moderate levels by 2010 (see Appendix B). No-till planting and narrow row planting are considered to be the most environmentally enhancing crop planting practices. No-till planting has substantial effects on sediment and nutrient loss and will be used to a moderate extent in this region by 2010. Narrow row planting will be used extensively, but its use will have only minor environmental effects. Soil protection practices, in particular reduced tillage and contour tillage, are predicted to have some beneficial sediment effects. Reduced tillage is the only soil protection practice that is projected to have a substantial impact on the Great Plains crop production system.

The most significant land development techniques that will result in moderately improved nutrient effects by 2010 are terraces and grass waterways. The crop planting practices predicted to similarily benefit the environment are no-till planting, strip cropping, and soil-plant analysis. Use of soil-plant analysis is projected to have widespread use levels by 2010, but the intensiveness of its environmental effect is minor.

Exhibit VI-6. Environmental implications of trends in regional crop production activities by type of pollutant under alternative growth scenarios, present to 2010, Great Plains Region (Region IV)

Crop Production Variable	Moderate Growth				High Growth				Change 1/			
	Sedi-ments	Nutri-ents	Pesti-cides	Salts/ other	Sedi-ments	Nutri-ents	Pesti-cides	Salts/ other	Sedi-ments	Nutri-ents	Pesti-cides	Salts/ other
	------ Rating of composite environmental effects 2/ ------											
INPUTS												
A. Quantity utilized												
1. Land	-3	-2	-1		-3.5	-2.5	-2.15		-0.5	-0.5	-1.15	0
2. Nutrients	1	-1	-		1	-1.5	-		0	-0.5	0	0
3. Pesticides	-	-	-0.5		-	-	-1		0	0	-0.5	0
4. Water for irrigation	-	-0.5	-	-0.5	-0.5	-1	-	-1	-0.5	-0.5	0	-0.5
5. Seeds and plants	1	1	0.5		1	1	1	0.5	0	0	0	0
6. Other (e.g. equipment)	-	-	-	-	-	-	-	-	-	-	-	-
B. Quality												
1. Land	-0.5	-0.5	-0.5		-0.7	-0.7	-0.7	-0.2	-0.2	-0.2	-0.2	-0.2
2. Nutrients	-	0.5	0		0	0.5	-	-	0	0	0	0
3. Pesticides	-	-	2		-	-	2	-	0	0	0	0
4. Water for irrigation	-	-	-		-	-	-	-0.5	0	0	0	-0.5
5. Seeds and plants	1	1	3	0.5	1	1	3	0.5	0	0	0	0
6. Other	-	-	-	-	-	-	-	-	-	-	-	-
MANAGEMENT PRACTICES												
A. Multi-season management												
1. Land development	5	5	5		5	5	5		0	0	0	0
2. Crop sequencing	-0.5	-0.5	-0.5		-0.5	-0.5	-0.5		0	0	0	0
B. Crop-season management												
1. Crop planting practices	4	4	1		4	4	1		0	0	0	0
2. Crop and field monitoring	1	3	5	3	1	3	5	3.2	0	0	0	0.2
3. Crop fertilization practices	-	1	-		-	0.8	-	-	0	-0.2	0	0
4. Pest control practices	-	-	4		-	-	3.8	-	0	0	-0.2	0
5. Water application practices	1	1	1	0.5	1	1	0.5		0	0	0	0
C. Non-crop season management												
1. Crop residue, control practices	1	1	-0.5		1	1	-0.5		0	0	0	0
2. Soil protection practices	2	2	-0.5		1.5	1.5	-0.7	-	-0.5	-0.5	-0.2	0
3. Moisture control practices	1	1	0.5	-0.5	1	1	-0.5	-0.5	0	0	0	0
4. Pre-plant fertilizer practices	-	-	-		-	-	-		0	0	0	0
5. Pre-plant pest control practices	-	-	-		-	-	-		0	0	0	0
OUTPUTS-RESIDUALS												
A. Residuals control												
1. Pollutant treatments	1	1	1		1	1	1		0	0	0	0
2. Other treatments	-	-	-		-	-	-		-	-	-	-
AGGREGATE ENVIRONMENTAL CHANGES 3/	3.1	3.4	3.9	0.6	2.8	2.9	3.7	0.4	-0.3	-0.5	-0.2	-0.2

1/ Change in difference between the high growth ratings and the moderate growth ratings.

2/ Region's workshop panel rating of each activity's composite primary media (water, soil, air) environmental effects in 2010 relative to the present period (scale = 0), by type of pollutant, and for alternative (moderate and high) growth scenario. Ratings range from +(beneficial) or -(adverse) (1 to 5) where 1 = minor and 5 = major.

3/ Aggregate environmental changes are the estimated total effects changes by type of pollutant for each growth scenario. Rating scale is also from ± (1 to 5) but it is applied to the aggregate effects.

Tabulated from Forms 5 and 8.

Crop and field monitoring practices are anticipated to substantially improve the region's pesticide effects, as these practices (including surface scouting, remote-sensing, and soil-plant analysis) are expected to reduce and/or improve the efficiency of pesticide usage. Specifically, surface scouting is predicted to increase from a minor to a moderate use level. Remote-sensing, considered almost a non-existent practice currently, is anticipated to be used by a major proportion of the crop production subsector by 2010. Soil-plant analysis is also expected to be used by a major proportion of the Great Plains producers. Although the intensiveness of their individual effects is minor, the overall improvement in pesticides is major.

Crop and field monitoring practices are also predicted to have a moderately beneficial effect on salt accumulation problems in the Great Plains.

3. Residual Controls

Residual control practices are expected to have relatively minor sediment, nutrient, and pesticide effects under the moderate growth scenario. Barrier strips and retention ponds are anticipated to be used to only a minor degree although the techniques are considered to be beneficial.

F. Western Crop Production Trends: Moderate Growth Scenario

The Western regional panel predicted that its crop production subsector, under moderate growth assumptions, would achieve aggregate environmental effects more beneficial in 2010 than currently (see Exhibit VI-7). A moderate level of sediment improvement, some improvement in nutrients and pesticides, and a minor improvement in salinity effects are expected. The salinity of soil, sediment gains in water, and salt levels in water are predicted to be the primary environmental concerns in the Western region by 2010.

The additional use of water for irrigation is expected to adversely affect the salinity concerns. However, land development and crop and field monitoring practices are anticipated to result in major environmental improvements in the West.

1. Inputs

Increasing levels of crop production input uses in the Western region, particularly irrigation water, are predicted to create potentially adverse sediment, nutrient, pesticide, and salt accumulation effects. However, beneficial changes in input form or quality are expected to help offset these adverse effects, except in the area of salt accumulations.

Exhibit VI-7. Environmental implications of trends in regional crop production activities by type of pollutant under alternative growth scenarios, present to 2010, Western Region (Region V)

Crop Production Variable	Moderate Growth				High Growth				Change 1/			
	Sedi-ments	Nutri-ents	Pesti-cides	Salts/ other	Sedi-ments	Nutri-ents	Pesti-cides	Salts/ other	Sedi-ments	Nutri-ents	Pesti-cides	Salts/ other
	Rating of composite environmental effects 2/											
INPUTS												
A. Quantity utilized												
1. Land	0	0	0	0	-2	-1	-0.5	-2	-2	-1	-0.5	-2
2. Nutrients	0.5	-0.5	0	0	0	-1	0	0	-0.5	-0.5	0	0
3. Pesticides	3	1.5	-1.5	0	2	1	-2	0	-1	-0.5	-0.5	0
4. Water for irrigation	-1.5	-1.5	-1.5	-1.5	-2	-2	-2	-2	-0.5	-0.5	-0.5	-0.5
5. Seeds and plants	0	0	0	0	0	0	0	0	0	0	0	0
6. Other (e.g., equipment)	-1.0	0	0	-1.0	-1	0	0	-1	0	0	0	0
B. Quality												
1. Land	-1.0	-1.3	-0.5	-1.3	-2	-2	-1	-2	-1	-0.7	-0.5	-0.7
2. Nutrients	0.5	-0.3	0	-1.5	0.5	-0.3	0	-1.5	0	0	0	0
3. Pesticides	0	0	4.3	0	0	0	4	0	0	0	-0.3	0
4. Water for irrigation	0.7	0	0	0	-1	0	0	-2	-1.7	0	0	-2
5. Seeds and plants	1.6	1.9	0.9	1.3	2	2	1	1	0.4	0.1	1.1	-0.3
6. Other	-	-	-	-	-	-	-	-	0	0	0	0
MANAGEMENT PRACTICES												
A. Multi-season management												
1. Land development	3.5	1.6	0.8	2.2	3	1	1	2	-0.5	-0.6	0.2	-0.2
2. Crop sequencing	-0.8	0	-0.4	-0.4	-1	-1	-1	-1	-0.2	-1	-0.6	-0.6
B. Crop-season management												
1. Crop planting practices	1.8	0.9	-0.4	-0.4	2	1	0	0	0.2	0.1	0.4	0.4
2. Crop and field monitoring	2.3	5.0	5.0	3.0	3	5	5	3	0.7	0	0	0
3. Crop fertilization practices	0.2	0.4	0.5	0	1	1	1	0	0.8	0.6	0.5	0
4. Pest control practices	0	0	0.6	0	0	0	1	0	0	0	0.4	0
5. Water application practices	1	0.7	0.4	0.6	1	1	0	1	0	0.3	-0.4	0.4
C. Non-crop season management												
1. Crop residue control practices	1.1	0	0	0	0	0	0	0	-1.1	0	0	0
2. Soil protection practices	2.1	1.4	0.8	0.6	2	1	0	0	-0.1	-0.4	-0.8	-0.6
3. Moisture control practices	1.3	0.8	0.5	0.8	1	1	0	1	-0.3	0.2	-0.5	0.2
4. Pre-plant fertilizer practices	0	-0.5	0	0	0	-1	0	0	0	-0.5	0	0
5. Pre-plant pest control practices	-0.8	0.8	0.8	0	0	1	1	0	0.8	0.2	0.2	0
OUTPUTS-RESIDUALS												
A. Residuals control												
1. Pollutant treatments	1	0.7	0.3	0	1	1	0	0	0	0.3	-0.3	0
2. Other treatments	5	2.5	1.0	3.5	3	1	1	2	-2	-1.5	0	-1.5
AGGREGATE ENVIRONMENTAL CHANGES 3/	3	2	2	1	2	1	1	-1	-1	-1	-1	-2

1/ Change in difference between the high growth ratings and the moderate growth ratings.

2/ Region's workshop panel rating of each activity's composite primary media (water, soil, air) environmental effects in 2010 relative to the present period (scale = 0), by type of pollutant, and for alternative (moderate and high) growth scenario. Ratings range from +(beneficial) or -(adverse) (1 to 5) where 1 = minor and 5 = major.

3/ Aggregate environmental changes are the estimated total effects changes by type of pollutant for each growth scenario. Rating scale is also from ± (1 to 5) but it is applied to the aggregate effects.

Tabulated from Forms 5 and 8.

Improvements in the qualities of pesticides and pesticide use rates, lower the pesticide effects. Changes in the quality of seeds and plants are also expected to benefit the environment somewhat.

2. Management Practices

Under moderate growth assumptions, land development is expected to substantially improve sediment effects and have some positive effects on salt accumulation. Crop and field monitoring, including such practices as surface scouting and soil-plant analysis, are predicted to effect major environmental improvements by reducing nutrient and pesticide effects, but have only moderately beneficial salt and sediment effects (see Appendix B). Soil protection practices, primarily reduced tillage, will cause minor beneficial sediment, nutrient, pesticide, and salt accumulation effects.

The land development practices that are anticipated to be utilized in the Western region are land forming, irrigation structures and soil profile modification (in other regions the principal land development practices utilized were terraces and grass waterways). These practices will provide moderate sediment and salt accumulation improvements and limited nutrient and pesticide effects.

3. Residual Controls

Land use and cropping restrictions are expected to be generally effective environmental management practices in the Western crop production subsector by 2010. These practices are projected to substantially reduce sediment and salt effects, to moderately reduce nutrient effects, and to slightly reduce pesticide concerns. Other residual control practices, such as barrier strips, retention ponds, and chemical controls are not expected to be of significant value for reducing adverse environmental effects, but their potential is recognized.

G. High Growth Rate Effects on the Five Crop Production Regions

The aggregate environmental impacts of the regional crop production subsectors in the future will be greatly influenced not only by the level of crop output produced annually, but also by its timing, i.e., how rapidly a specified, higher output level must be reached. Each of the regions was projected to reach output levels from 13 to 17 percent higher by 2010 under the high growth scenario compared with each region's moderate growth scenario output level. Thus, not only are the regional output levels higher, but they are to be achieved within the same time frame. Such growth places additional demands on those beneficial environmental management practices and trends if the necessarily adverse environmental implications of growth are to be counter balanced.

The high growth scenario projections and assumptions (see Section IV) were presented to the regional panels so that they could determine and assess those environmentally related trends that would most likely be affected by this growth situation. In contrast to the moderate growth scenario that specified an increasing crop production index from 100 (1972-1974) to 171 (2010), the high growth scenario depicted a crop production index increase from 100 to 196 (2010). The production indices in the intermediate years for the high growth scenario showed the greatest rate of growth occurring before 1985. The production indices used by the panelsits are shown in Exhibit IV-2 for the U.S. and the study's five crop production regions.

The index values indicate the level of growth that each region is to attain. The panelists projected the environmental impacts of the activities required of the crop production subsectors to meet these goals. 1/

1. Northeastern Region

Production increases under the high growth scenario were 14 percent greater than the production requirements of the moderate growth scenario. This additional production is expected to be partially met through shifting to the use of better land by 2010. This trend, currently underway, of shifting land use--from Class IV-VIII to available Class I-III land--is an option not generally available in other regions.

Under the high growth scenario, the aggregate environmental impacts of crop production activities in the Northeastern region are identical to those under the moderate growth scenario: a minor improvement in sediments, no change in nutrients and a minor improvement in pesticides compared to the current situation (see Exhibit VI-3).

There were, however, some variations in the environmental effects of various components under the two scenarios. For example, the increased use of nutrients that could result in a minor nutrient-effect degradation was essentially offset by non-crop season management practices--soil protection measures and pre-plant fertilizer practices.

2. Southeastern Region

Under the high growth scenario, the aggregate production level of the Southeastern region must increase 14 percent above the level required under the moderate growth scenario.

1/ The study's evaluation procedures, as explained in Appendix A, were partially modified by bypassing Form 7 which would have documented with rating values each trend's change in its projected extensiveness of use by 2010. Because of time constraints, these changes were only implicitly evaluated by directly assessing the trend-grouping environmental effects in 2010 relative to current (1977) conditions.

The resulting aggregate environmental impact of the required crop production activities is anticipated to be slightly less favorable than under the moderate growth scenario, but the sediment, nutrient and pesticide effects still show minor improvement over the current situation (see Exhibit VI-4). Although the overall environmental impact of nutrients did not change under the two scenarios, the input quantity and quality impacts were adverse. This was offset by further improvements in management practices. Aggregate pesticide changes were less favorable because of increased quantities of pesticides and reduced residual controls and this resulted in fewer beneficial impacts that were not completely counterbalanced by the improvements resulting from crop season management practices. Sediment effects were projected to improve by only a minor extent because of minor (compared to some) improvements in multi-season management practices. Even though the composite environmental effects are not as favorable as under the moderate growth scenario, the panelists nevertheless projected minor beneficial impacts when compared to the present time.

3. Cornbelt/Lake States Region

The high growth scenario requires a 13 percent increase in production over that for the moderate growth scenario in this region.

The environmental impacts of producing the increased quantities results generally in an environmental degradation, compared to the impacts of the moderate growth scenario (see Exhibit VI-5). Nevertheless, compared to present conditions, the environmental effects of sediment are projected to show some improvement, although some environmental degradation from nutrient effects and minor degradation from pesticide effects are anticipated.

In much the same manner as for the moderate growth scenario, adverse sediment effects result from the increased use of lower class land, crop sequencing and crop residue control practices. The beneficial sediment effects result primarily from improved land development, crop planting, and soil protection practices. Residual controls were slightly less beneficial under the high growth case than under the moderate one. The aggregate sediment impact was that there would be some improvement as was also anticipated under moderate growth.

By contrast, compared to current conditions, adverse nutrient and pesticide aggregate effects are projected. The increased use of improved inputs and management practices inadequately compensate for these input-related effects.

4. Great Plains Region

The high growth scenario requires a 17 percent increase in the Great Plains region's crop production over that for moderate growth in 2010. Even so, the environmental concerns associated with crop production activities are expected to be only marginally affected relative to the moderate growth case. Sediment, nutrient and pesticide effects continue to be moderately improved and salt effects will be slightly improved over present conditions. These high growth effects are only slightly less beneficial relative to the present than is anticipated with moderate growth (see Exhibit VI-6).

In order to meet production levels, large quantities of inputs are required, but the environmental effects of these are more than countered by improvements in the quality of inputs and in environmental management practices.

5. Western Region

Crop production under the high growth scenario will increase 16 percent above that for moderate growth in the Western region. Compared to present conditions, this increased production is expected to cause minor adverse salt effects (-1), whereas, under the moderate growth case, minor beneficial salt effects (+1) were anticipated. Continuing beneficial aggregate sediment (+2), nutrient (+1), and pesticide (+1) effects are expected in 2010 compared to present conditions under high growth, but these ratings are less beneficial than the moderate growth case, i.e., each effect was rated one point lower.

The adverse salt effect, primarily, results from increased land use, lower quality water for irrigation, and less effective residual controls. However, these inputs' adverse sediment, nutrient and pesticide effects are offset by crop and field monitoring, land development, and residual control practices.

The composite environmental effects under high growth are worse than under moderate growth with the largest difference being the salt effect. However, only the salt impacts are expected to be more adverse than present conditions.

SECTION VII

EXOGENOUS FACTORS

The crop production system has many internal factors that affect its outputs and their attendant environmental effects--such as trends in input use, management practices and residual treatments as presented in the preceding section. Additionally, the crop production system is affected by external events that affect its main components and, thus, its environmental implications.

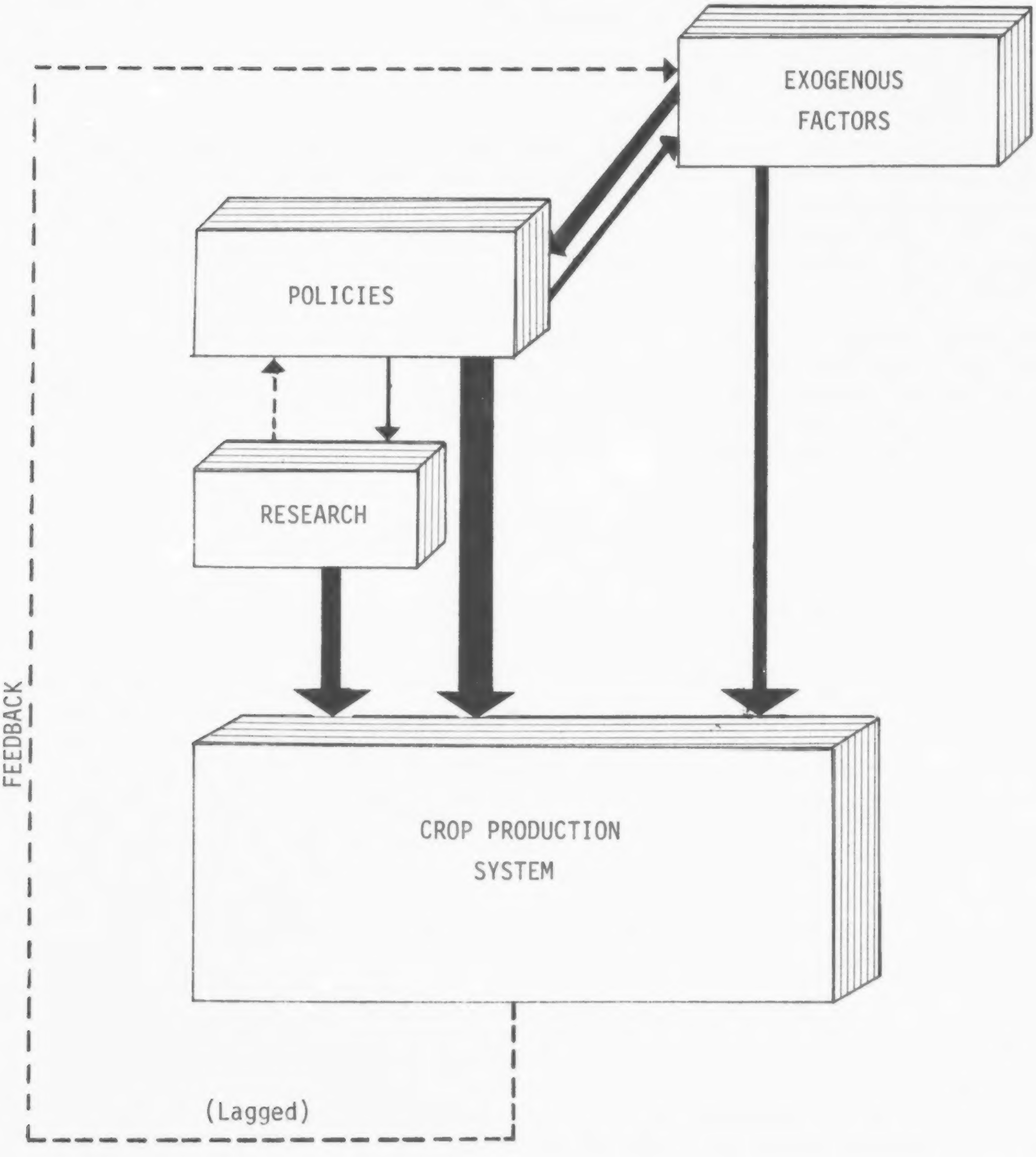
Three main types of external events that are regularly of concern to the regional crop production subsectors are exogenous factors, governmental policies and research developments. This section focuses on the major exogenous factors identified by the region's panels; policy concerns and research needs are discussed in Sections VIII and IX.

A. Conceptual Framework

As depicted in Exhibit VII-1, exogenous factors, government policies, and research developments may each directly affect the crop production system during a given time period. In addition, these external conditions are also interrelated and can partially affect one another. Various exogenous factors may be at least partially controlled by government policies that alter the impacts of these exogenous factors (e.g., price supports and import quotas may be protective policies affecting a strategic commodity faced with irregular foreign competition). In many other cases, research programs can be initiated in conjunction with government policies, or, inversely, policy analysis research can be conducted to help establish policy positions or formulate policy implementation plans. Ultimately, however, during a given period, these three types of external events do, both individually and collectively, affect the crop production system and, consequently, its environmental impacts.

Additionally, as depicted in Exhibit VII-1, feedback to these external events from the crop production system occurs over time. In general, the lagged crop production system performance characteristics may be considered, also, as external events. This lagged feedback relationship is not unlike an "exogenous factor" in a dynamic systems analysis framework. Although often this type of exogenous feedback readily results in policy and research implications, it is instructive to first view feedback as an exogenous factor.

Exhibit VII-1. Conceptual framework for external events that affect the crop production system


EXOGENOUS FACTORS
POLICIES
RESEARCH
CROP PRODUCTION SYSTEM
FEEDBACK
(Lagged)

This analysis of the environmental implications of the crop production system's exogenous factors utilized the above conceptual framework for the assessment that follows. Such a framework was needed in order to more effectively assess each of the five regional workshop panel's separate and composite statements of their principal exogenous factors, policy concerns, and research needs.

B. Types of Exogenous Factors

Numerous specific exogenous factors were identified by the workshop panels, and they were subsequently categorized--by their main effect on the crop production system and by their major subject areas--as follows:

Input-Related
- Technology development
- Aggregate resource use
- Agricultural finance

Management-Related
- Technology use restraints
- Education/extension
- Environmental plans

Output-Related
- Economics-markets
- Residuals

System-Related
- Institutional
- Climate/weather

One or more specific exogenous factors were identified within each subject area as summarized in Exhibit VII-2 and as discussed in detail below. These subject area categories are indicative further of the associative relationships that exist among the crop production system's exogenous factors, government policies, and research needs. In most instances, the exogenous factors (including the lagged responses of the crop production system) are the causal agents for both policy concerns and research needs.

When the workshop panels' assessments were further analyzed, they indicated that although the panels were relatively optimistic about the crop production system's ability to realize the 2010 moderate growth levels, they were less confident in the achievability of the 2010 high growth levels. The panels, also, anticipated that the latter scenario growth levels would be accompanied by relatively adverse environmental effects compared to the moderate levels.

It is important to note, also, that the nature of the panels' tasks resulted in their concentration upon those exogenous factors whose influence would negatively effect environmental concerns. To be sure, not all exogenous factors will be potentially harmful; however, the purpose of the present study is to examine more closely those that are.

Exhibit VII-2. Summary of major exogenous factors affecting the crop production system

Crop Production System Component and Subject-Area	Exogenous Factor
INPUT-RELATED	
. Technology development	. Uncertain resource availability . Questionable resource-use efficiencies
. Aggregate resource use	. Potentially inappropriate land use . Potentially declining water supplies . Unassured energy availability
. Agricultural finance	. Inadequate capital financing
MANAGEMENT-RELATED	
. Technology use restraints	. Restricted pesticide use . Potential fertilizer use constraints
. Education/extension	. Unassured implementation of new management systems
. Environmental plans	. Impending requirements for state and local environmental plans
OUTPUT-RELATED	
. Economics-markets	. Market instabilities . Irregular export markets
. Residuals	. Composite environmental effects
SYSTEM-RELATED	
. Institutional	. Insufficient government coordination . Inadequate agricultural representation . Insufficient basic science research
. Climate/weather	. Uncontrollable climate/weather

Source: Compiled by Development Planning and Research Associates from information received from the regional panels.

C. Input-Related Exogenous Factors

The regional panels identified a number of input-related exogenous factors that are of increasing concern for sustaining crop production growth in the future. These factors, although largely uncontrollable by the crop producers themselves, will be fundamentally affecting the quantity and quality of the system's production inputs, partially determine the system's ability to achieve its desired 2010 production levels.

1. Technology Development Factors

This category of exogenous factors particularizes those that partially determine the potential yields and environmental effects of individual producers. More specifically, the panels recognized that individual producers will be dependent upon both the technological quality and quantity of such resource inputs as chemicals, water, and equipment. Of major concern will be (a) the uncertainty of such resource availability and (b) the questionable efficiency of these resources.

a. Uncertain resource availability. Recently, producers have been affected by real or potential resource-input shortages (i.e., fertilizers in 1973-74, seasonal-use agricultural chemicals, and farm equipment). Such shortages, beyond individual producer control, obviously can curtail production, and indeed, merely potential shortages can result in production losses by the untimely or imbalanced distribution of eventual resource stocks. Such an exogenous factor can be addressed by more adequate planning and by recognizing its importance. For instance, the fact that natural gas supplies are critical to the production of nitrogen fertilizer should be realized and those supplies allocated on a priority basis to assure the continuance of agricultural production supplies and a forestalling of production cutbacks.

Too, while the quantity of available inputs may be critical, their quality is potentially of even greater significance for the environmental effects of the crop production system. Seed and plant genetic improvements can provide increased yields with the same resource base; improved pest and disease resistant strains can reduce the present pesticide levels; improved chemical formulations will affect per acre rates of use; and especially designed planting and tillage equipment will alleviate equipment-related environmental effects.

Exogenous factors do exist, then, that can affect both the quantities and qualities of input resources available to the individual producer and over which he can exert little or no control. The study's panel could only express their concern for the uncertainties that surround the availability of such resources.

b. Questionable resource-use efficiencies. The long-term output capability of the crop production subsector is partially dependent upon continuing resource-use efficiency improvements and these, in turn, are largely determined by off-farm sources--both public and private. Two resources are of major concern--water and energy.

Especially in the Western region, where irrigation water supplies are critical, improved crop irrigation water-use efficiencies achievable by individual producers will become increasingly more important for meeting crop output projections. New methods of irrigation--drip, trickle and spray--should be developed that are more efficient than the major current methods of furrow and basin. Continuing resource-use efficiency developments are regarded as essential by many toward meeting future production projections.

Energy use efficiency improvements are also desirable in crop production management--both directly and indirectly. Crop production is not regarded as especially energy intensive with respect to direct energy use, but reduced tillage methods can be developed that will lessen direct energy uses. Indirectly, through resources such as fertilizers, other agricultural chemicals, equipment, and irrigation water delivery, the crop production system utilizes significant supplies of energy and technological developments in these areas can result in greater energy conservation. Potentially, then, greater direct and indirect energy use efficiency is possible.

2. Aggregate Resource Use

This category of exogenous factors identifies those that affect regional or national crop production yields and environmental effects as opposed to those that are more site specific. The panels identified three factors of chief concern: (a) potentially inappropriate land use, (b) potentially declining water supplies, and (c) unassured energy availability.

a. Potentially inappropriate land use. In particular regions throughout the nation, 2010 moderate and high growth levels may become more difficult to achieve as a result of land use changes. Particularly, increasing amounts of prime farmland (Classes I, II, and III) are being diverted from agricultural production and into such concerns as urban-area expansion, transportation networks, and land purchases for non-production purposes (public and private). These exogenous uses are causing the loss of agricultural land resources in the aggregate and oftentimes these land uses are effectively irreversible.

As discussed earlier in this report, the national crop production subsector currently uses about 350 million acres of land (27% of the private land in the U.S.). The projected need in 2010 for farmland is approximately 450 million acres. USDA has estimated, in 1975, that approximately 111 million acres of potential cropland remain (Classes I-III), but no assessment was made of potential cropland losses. In the Cornbelt/Lake States region, the study's panel projected that cropland will be fully utilized before 2010 even under moderate growth assumptions. Hence, aggregate land use patterns are of growing concern.

b. Potentially declining water supplies. In much of the Western region and in portions of the Great Plains and other regions, irrigation water supplies are either currently or potentially limited. Though both surface water and groundwater resources are currently utilized in crop production, municipal and industrial users are usually given priority if allocations are necessary.

Even though some groundwater aquifers are effectively depleted and their wells abandoned and even though, also, some surface water sources are fully utilized under present demand, the aggregate, national use of irrigation water has been steadily increasing through the utilization of other water supplies. The panels were concerned, however, that increasing demands will eventually exceed those supplies that are economically available.

The exact dates and locations of projected groundwater depletions and surface water shortages are not fully known, yet, at best, there is an indefinite outlook for the continued growth of irrigated crop production to 2010. Expansions should continue in the Great Plains and the Southeastern regions in the near-term, but the Western region (except the Northwest) will experience increasing water shortages for agricultural production.

c. Unassured energy availability. The national crop production subsector essentially has no captive fossil-fuel energy sources. Hence, like other energy users, crop producers are dependent on external sources for energy. In part, because of recent energy shortages, there exists a concern about the availability of sufficient energy to attain the projected production levels as specified in this study's growth scenarios.

Although the aggregate direct energy requirements for production, harvesting, and assembly are lower than the system's indirect energy requirements for fertilizers, other chemicals, equipment manufacturing, and transportation, both energy requirements are essential. Doubtless, the panels' concerns that the exogenous factor of energy availability will be a determinant of both future yields and the system's modes of production and their consequent environmental effects will be a general concern in the future.

3. Agricultural Finance

This category of exogenous factors, though not specifically agricultural in nature, may well be a most consequent determinant of future production and its resulting environmental effects. Both the aggregate financial requirements of the crop production sector and those of individual producers will increase in the future and will compete with frequently more advantageous sectors of the economy for national, regional, and local financial resources.

Inadequate capital financing. The capital requirements for crop production activities are now typically high per farm, especially for new operators who invest in land, tractors, tillage machinery, combines, trucks, and perhaps, irrigation systems. Furthermore, working capital (or production credit) is often required to purchase fertilizers, pesticides, and off-farm labor.

Commercial credit sources--banks and some public-based institutions, e.g., the Federal Land Bank and the Production Credit Association--are major current lenders. However, often times they are inadequate to meet the increasingly larger loan requirements and acceptable repayment provisions. The latter factor which stems from the inability of crop producers to generate cash flows for loan repayments during either adverse growing periods or during periods of low economic returns due to depressed market prices is of especially frequent concern. In general, improved sources and terms of credit are desired and until they are, their potential or real inacessibility will be a significantly limiting exogenous factor, e.g., a limit to the proper implementation of BMP's.

D. Management-Related Exogenous Factors

Some of the exogenous-factor concerns expressed by the workshop panels would primarily affect crop producers' management capabilities. Three general types of factors discussed were technology use constraints, education and extension needs, and environmental plans affecting the crop production system.

1. Technology Use Constraints

Technology-constraining exogenous factors were considered of potentially high significance in the crop production system's attempts to achieve 2010 crop output levels. Although the panels were cognizant of the future need to guard against inadvertent environmental damage, they were concerned that policies related to agricultural fertilizer, pesticide and other chemicals usage become not counterproductive to the overall concerns of crop production system management. Two specific areas of concern were frequently cited: (a) restricted pesticide use and (b) potential fertilizer-use constraints.

a. Restricted pesticide use. The presumed advances in agricultural chemical technological developments are now regularly questioned by the Environmental Protection Agency because of the chemicals' toxicity, persistence, lack of target-species specificity, and other potentially hazardous characteristics, including apparent carcinogenic effects of some on humans who may be exposed to such materials. Various agricultural chemicals have been either banned or restricted-in-use (e.g., DDT, chlordane, heptachlor). Most of these restricted materials are insecticides because their higher potency requirements, in exceeding those of herbicides and others, pose greater immediate threats to man and other biological species.

A major concern of crop producers is that effective chemical alternatives are not available for various restricted materials with the resultant loss of production. Furthermore, integrated pest management practices--which potentially combine chemical, biological, and mechanical practices--have not yet been adequately developed and proven. Hence, there is simply a growing concern among crop producers that continued pesticide restrictions despite the lack of viable alternative controls, may prevent the attainment of the projected output levels and create other environmental impacts through land-based output options.

b. Potential fertilizer use constraints. Although no fertilizer use restrictions have yet been imposed by EPA, there has been speculation regarding such constraints as a means of controlling nutrient losses and, thus, water nutrient gains. To most crop production specialists, the implicit reasoning is counter-productive and would not accomplish the desired water quality goals while inhibiting the realization of the crop output goals.

Basically, an optimum nutrient supply exists that will produce healthy plants with both a vibrant root system and a desirable canopy--properties that significantly help reduce soil erosion and nutrient losses and increase output. Other management practices such as the timing and method of fertilizer applications or the improving of fertilizer forms are much more germane alternatives to achieving environmental-effects control while also achieving the output goals. Furthermore, the probable impact of fertilizer constraints would be to worsen aggregate environmental effects since more marginal land would be cropped and result in a greater total loss of soil nutrients and pesticides.

2. Education/Extension

The panels considered this management-related exogenous factor one of potential significance because of its implicit relationship to all others. The success of technological improvements in agriculture is importantly dependent upon the crop producers knowledge of and access to such improvements and their application. The role of education in promulgating such knowledge is fundamental.

Unassured implementation of new management systems. The panelists expressed concern that a satisfactory education-extension effort be maintained to assure that as environmentally improved management practices are developed, they be effectively promulgated throughout the nation.

Because many crop producers exist--over one million--a vital link in the adoption of improved management practices is simply providing for the effective dissemination of pertinent information. The Federal and State Extension Services and selected state educational institutions have an implied role in this process, but neither their role nor their specific responsibilities toward assuring implementation of new environmentally related management practices are adequately known.

3. Environmental Plans

Impending environmental plans are, collectively, a management-related exogenous factor that is directly related to the crop production sector's environmental (and output) effects. The panels cited as specifically consequential the as-yet unknown results of the application by state and local planning agencies of the requirements of federally mandated water quality control legislation.

Impending requirements for state and local environmental plans. The agriculture sector generally and crop producers particularly are anticipating an increasing degree of environmental control. The main anticipated near-term type of activity involves state and area-wide planning for nonpoint source (NPS) water quality improvement as mandated under Section 208 of

PL 92-500 and PL 95-217, the Federal Water Pollution Control Act (as amended)--or 208-NPS plans, for brevity. (Additionally, PL 95-217, the Clean Water Act of 1977 contains provisions for NPS planning, e.g., completion of 208 plans by the states within three years.)

The environmental planning required by this legislation is still in the early stages of development; thus, its effects on the crop production subsector are not known. Based on anticipated developments, a major thrust of subsequent programs will be toward the implementation of best management practices (BMP's) by producers. However, such BMP's are yet neither adequately defined nor their cost effectiveness assessed. The degree of their acceptability and expected level of implementation cannot, consequently, be determined.

A further concern by many of the workshop participants was that the 208-NPS planning process often did not obtain adequate input from agricultural representatives. Hence, a latent concern exists that the resultant planning recommendations will lack an adequate data base from the perspective of crop producers.

E. Output-Related Exogenous Factors

Some of the exogenous factors presented and assessed by the workshop were primarily output-related. In particular, the aggregate output of the crop production system is itself an exogenous, partially uncontrollable, factor that has macroeconomic effects. Such effects influence producers' subsequent behavior, including their environmental management decisions.

1. Economics-Markets

The panels considered as an exogenous factor the crop production system's annual crop output. Less a paradox than it seems at first glance, the considering of the sector's own production as an exogenous factor is but a recognition that the instability of both crop supply and demand becomes a determinant of planting practices and, hence, of their resultant environmental effects. The crop producers, in responding to short-run market conditions, may adopt temporary practices that, in the aggregate, are detrimental to a regional or the national environment. The panels were concerned, then, that domestic and export market instabilities will result in crop producer behavior that is inimical to best long-term management practices.

a. Market instabilities. The aggregate, annual crop output is, itself, a type of exogenous factor, i.e., the total supply cannot be strictly controlled due to varied plantings and yields. Additionally, the demands for specific crops may vary from period-to-period. Both the supply and demand variations are reflected in market prices, which in turn affect subsequent producer behavior, i.e., a lagged crop production system response.

Various types of market instabilities are inherent in the U.S. market system and, though self-correcting, these instabilities are disruptive. For example, an abnormally low supply, with consequent high prices, may induce abnormally high plantings of a new crop and lead to a later over supply.

In other instances demand-induced instabilities have occurred, such as a short-term increase in foreign demands and resulting high prices. The subsequent production increases followed by reduced demands results in an over supply with lower prices.

Despite the apparent need for improving supply-management and/or demand management in the aggregate, there remains an intense desire to provide open choices for crop producers in crop selection and management. Farm legislation provides for various types of checks and balances, but new supply-demand factors have continued to regularly occur.

In summary, market instability is a major exogenous factor for many crops. The sources of instability are varied, and attempts to control either supply or demand components create other problems or concerns. Future alternatives to improve market instabilities are unclear, although the belief exists that more effective environmental management could be expected with improved market stability.

b. Irregular export markets. In recent years, export sales for selected U.S. crops have varied substantially, causing both price fluctuations and changes in crop production patterns. Since the price changes affect the entire U.S. crop sales not simply the export markets, the associated changes in crop production patterns can be extensive and can result in environmentally disruptive management practices.

The short-term gains due to increased, but irregular, exports are quickly offset by depressed markets following declines in export demands. False expectations are generally not recognized until various commitments have been made by crop producers which result in additional, on-farm adjustment requirements.

Thus, irregular export markets are a serious exogenous factor. In the long-term, the regularity and the level of export demands may well become critical.

2. Residuals

This category of exogenous factors recognizes that crop production residuals are, collectively, a major source of environmental pollution. However, because the collective, aggregate environmental effect of the individual crop production pollutants is realistically outside the control of individual producers, these aggregate residuals may be realistically viewed as an exogenous factor subject to public as well as private analysis and control.

Composite environmental effects. Crop production residuals are those nonharvested byproducts of production that may become pollutants in the soil, water and air media. Individual producer's residual-pollution effects are seldom significant; however, they may become consequential when they are combined with all other sources of pollution, e.g., both point and nonpoint sources, including natural pollutants, in water receptors.

Because the individual producer's pollutant effects are usually minor, the composite of all sources' environmental effects should be viewed as an exogenous factor. Within the context of this study that viewpoint is generally acceptable, since, also, the trends assessments and environmental concerns assessments are considered in aggregate terms. Eventually, however, the individual producer's must make appropriate adjustments in the use of inputs, management practices and residual treatment as a contribution to the control of the externality-effects of all composite pollutants in environmental media.

F. System-Related Exogenous Factors

Because exogenous factors identified by the panelists could potentially affect the crop production system in more than one catetory (i.e., input, management practices and output), they are included here under the more general system-related category. The panels identified two major exogenous factors of chief concern here: (a) institutional, and (b) climate/weather. Institutional concerns primarily involve the effects of federal, state and local governments. Climate/weather concerns involve the natural effects of climate and weather on crop production and man's attempts to compensate for or to capitalize on these effects.

1. Institutional

This category of exogenous factors is concerned primarily with three prevailing conditions that affect the environmental effects of the crop production system rather directly. The panels, in the first instance, pointed to the uncertainties that exist in the present and future administration of local, regional, and national regulations governing environmental quality standards and in the potentially conflicting interests and attitudes that may determine those requirements. In the second instance, the panels felt that too frequently environmental standards and the means of achieving these standards have been determined without proper consideration being given to the needs of agriculture, *per se*. Thirdly, the panels identified as an influential exogenous factor the present decreased attention on basic agriculture research.

a. Insufficient government coordination. One of the main system-related exogenous factor concerns identified was the seeming confusion over the respective roles of federal, state and local governments in environmental quality management. The basic assumption that state and local governments may adopt specific environmental legislation so long as it meets minimum federal requirements becomes problematic at the local level because (1) the minimum federal standards are often unknown, e.g., 208-NPS plans and (2) the state or local governments can adopt even more stringent controls. So long as such confusion prevails, individual producers will be unable to adopt long-term, dependable management practices that may require extensive capital investments.

The confusion is further emphasized when the interrelationships among soil, water, and air quality effects are recognized, relationships so pronounced that measures taken to address one environmental problem may well adversely affect others. Additionally, governmental regulating bodies must eventually recognize their responsibility to secondary ecosystem effects. For example, the dispersement of municipal sludges on agricultural lands may result in heavy metal concentrations in the soil and in water receptors that may adversely affect various ecosystems.

b. Inadequate agricultural representation. The panelists generally believed that there has been insufficient agricultural representation in the environmental planning that affects crop production. More direct representation and input are desired in order to more fully assess the effects of proposed environmental actions. Such effects would include production output considerations as well as the crop production system's environmental effects and the expected directions that producer behavior would take, given specific proposed programs. Furthermore, the agriculturists should be asked to identify potential alternative actions that, when evaluated, may produce a more nearly optimal output/environmental effect balance.

c. Insufficient basic science research. U.S. agriculture has had a long history of institutionally supported (public and private) basic plant and animal science research. Such research (including soil science, also) has produced a capital stock of genetic and other technological developments that have been tested, refined, and implemented to help create the U.S. agriculture sector as we know it today. However, agricultural scientists believe that this past capital stock of basic science development is being eroded without an adequate effort toward replenishment and growth; consequently, in a time of even greater expected need than currently--this apparent inadequacy of basic science research is considered a significant adverse exogenous factor.

Basic science research is, then, regarded as an exogenous factor by the crop production subsector, in part because its findings are not directly applied by producers, and, in part, also, because of the declining influence of agriculture in the political processes that previously provided for relatively greater support of basic science research.

2. Climate/Weather

An obviously significant exogenous factor for the crop production sector is that of the influence of uncontrollable climate and weather. Many of the potential and on-line technological advancements and management-related practices of beneficial environmental effects will be most significantly affected by prevailing climate and weather conditions. To the extent that such conditions can be controlled or compensated for they will, themselves, contribute to agriculture's environmental effects.

Uncontrollable climate/weather. The crop production system is dependent on natural climate and weather patterns for its crop outputs. Basically, weather and climate are uncontrolled exogenous factors; some regions are more dependent than others for natural precipitation, solar radiation, and crop-season soil and air temperatures.

Attempts are being made to establish some control over weather phenomena, yet, in the foreseeable future, the crop production system as a whole expects to operate with climate and weather as exogenous factors. Importantly, though, simply the improvement in weather prediction may be among the most important factors toward improved environmental quality management. The timing of such management practices as pesticide applications or changes in the method of performing operations can be beneficially controlled with improved weather predictions.

G. Regional Exogenous Factor Differences

Regional differences in the exogenous factors identified by the panelists were readily apparent. Although taken as a whole, the regional exogenous factors, e.g., land use, technology developments and market instabilities were similar, the specific factors of concern varied in kind and in importance by region. The exogenous factors and their relationships to the crop production system are shown in Exhibit VII-3, where the number indicates the rank in importance of that factor to the region.

1. Input Related Factors

Factors related to technological developments were cited as major concerns by three regions. The Great Plains panel ranked potential governmental restrictions on use of technology, especially agricultural chemical, as its principal concern. Possible effects indicate reduced production levels, increased runoff resulting from restricted plant growth, and a lessening development of new agricultural chemicals because of regulatory policies.

The Northeastern region ranked biological nitrogen fixation capability as its second most important exogenous factor because of its potential to reduce soil and nitrogen losses. The Cornbelt/Lake States identified as its third most important factor, yield and quality improvements--inputs that allow more product to be produced with less land and energy and that result in effectively increasing land supply and making possible the use of less intensive production methods.

Aggregate resource use exogenous factors were identified as of primary concern by three panels. In the relatively densely populated Northeastern region, land use, in particular urban encroachment, was cited; however, population pressure on price and unique land resources can and is being countered by legislative action to remove agricultural land from the development market. An associated factor--food production near population centers--was ranked third because of its potential to take advantage of prime land near cities and simultaneously reduce energy costs. In the

Exhibit VII-3. Ranking of exogenous issues with environmental implications for the regional crop production sector

	Northeastern	Southeastern	Cornbelt/ Lake States	Great Plains	Western
Input-Related					
Technology Development			3		
Nitrogen fixation	2				
Restrictions				1	
Aggregate Resource Use					
Land use	1				
Land near cities	3				
Water					1
Energy		3			3
Management Practice Related					
Education/Extension		1			
Environmental Plans					2
Output-Related					
Economics-markets					
Exports			1		
Market instabilities		2		2	
System-Related					
Climate/weather			2	3	

Source: Compiled by Development Planning and Research Associates from information received from regional panels.

Western region, water supply (i.e., its allocation among competing use categories, its cost as related to cropping patterns, its conjunctive use, and its interbasin transfers) was of utmost concern.

Total energy requirements, costs, and availability were ranked third in two regions - the Southeastern and the Western.

2. Management Practice Related Factors

Exogenous factors related to management practices were identified by two panels as concerns. The Southeastern panel ranked mission-oriented basic research first. Such research includes that concerned with improving nitrogen fixation, photosynthesis, and genetic research and its application to best management practices.

The Western region ranked Section 208 plans including the identification and definition of best management practices and implementation procedures as their second ranked exogenous issue.

3. Output-Related Factors

Economic and market related factors were ranked as major concerns by three panels. The Cornbelt/Lake States cited high export demand market as its primary concern. The panel emphasized the potential results of high commodity prices and decreasing restrictions over resource use. The panel pointed out that these conditions could encourage the "plow-up" of environmentally fragile land and increase fertilizer and pesticide use in a region which could be expected to supply a large portion of the exported food and feed grains.

Two regions, the Southeastern and Great Plains, ranked economic or market instabilities as their second most important exogenous issue. Cost-price relationships, particularly in regards to farm size and the prices of production inputs such as land and fertilizer were specifically mentioned.

4. System-Related Factors

Two regions mentioned the climatic effects on agriculture. In ranking this factor second, the Cornbelt/Lake States panel concluded that there is a need to develop better short and long run predictions of weather so that improved strategies in environmental protection can be developed, including the timing of field operations, irrigation and chemical applications. In addition, adverse climate cycles and such drastic changes in climatic patterns as extreme drought were specifically mentioned by the Great Plains panelists in ranking climate cycles as its third ranked concern.

Inherent in all the above mentioned factors identified by the regional panels are associated policy concerns and/or research needs.

SECTION VIII

POLICY CONCERNS

The performance of the crop production system is regularly affected by government policies that seek to modify or control the system and its related concerns in publically beneficial ways. Such policies reflect a concern not only with the crop production system's past output performance, but, also, they attempt to consider those exogenous factors that may affect the system's future performance characteristics as well. And, as was described above in Section VII-A: Conceptual Framework, government policy is one of the three main types of external events--policy concerns, exogenous factors, and research developments--that affect crop production.

This section focuses on those policy related concerns that were identified by the workshop participants. These policy concerns reflect some of the crop production subsectors' on-going or recent public issues, and perhaps more importantly for improving environmental management, these policy concerns reflect, also, anticipated future issues.

The specific policy concerns are identified basically with either (1) exogenous factors that often have indirect environmental effects or (2) internal crop production system factors that generally have direct environmental effects. In the first instance, government policies may primarily affect the exogenous factors themselves as a means of controlling their influence on the U.S. crop production system, e.g., international trade policies protective of domestic production. In the second instance, government policies may seek to affect behavior of producers directly.

A. Types of Policy Concerns

The regional panels of the workshop identified a broad range of policy concerns which each panel considered most germane to its region's crop production subsectors. These concerns were, by major subject-area, analyzed and then categorized from a national perspective according to their main effect on the crop production system as follows:

Input-Related
- Technology development
- Aggregate resource use
- Agricultural finance

Management-Related
- Technology use restraints
- Education/extension
- Environmental plans

Output-Related
- Economics-Markets
- Residuals

System-Related
- Institutional
- Climate/weather

One or more specific policy concerns were identified within each of these categories as shown in Exhibit VIII-1. Each of these specific policy concerns is discussed below; however, the subject-area categorization shown above provides the main structural framework that links many of the exogenous factors, policy concerns and research needs of the crop production system (see Section VII-A, Conceptual Framework, for a further discussion of the prospective linkages among these system-related variables).

B. Input-Related Policy Concerns

The U.S. crop production system has a long history of increased productivity which has enabled it to sustain growth on a relatively constant cropland base. Under the projected growth scenarios of this study, crop output indexes are expected to rise to 171 and 196 (where 1972-74 = 100) by 2010 under the moderate and high growth scenarios, respectively. Such growth is only feasible with continued productivity gains for the potential cropland increases are generally limited (especially in the Cornbelt/Lake States region where cropland will be limited by 2010, and in the Western region where water supplies are limited).

The following policy concerns emphasize some of the major input-related issues which will need to be addressed effectively if needed growth is to be achieved.

1. Technology Development

In considering those policies that should be forwarded to meet the projected 2010 crop yield levels and to lessen the potential environmental effects of such production, the panels emphasized the importance of four policy goals: (a) the achievement of plant genetic improvements, (b) the development of improved agricultural chemicals, (c) the fostering of improved equipment design, and (d) the supporting of resource-use efficiencies. In each instance, the panels recognized the dual importance of achieving production goals and of enhancing the environmental effects of the crop production sector.

a. Sustain plant genetics improvements. Plant genetic research is a significant means of developing those plant attributes necessary to production increases and environmental enhancement. An expressed belief among plant

Exhibit VIII-1. Summary of major policy concerns affecting the crop production system

Crop Production System Component and Subject Area	Policy Concern
INPUT-RELATED	
. Technology development	. Sustain plant genetics improvements . Support agricultural chemicals improvements . Foster equipment improvements . Support resource-use efficiency improvements
. Aggregate resource use	. Subscribe to land uses more protective of agriculture . Improve upon aggregate water uses . Maintain energy supplies and forms
. Agricultural Finance	. Improve agricultural credit and financing
MANAGEMENT-RELATED	
. Technology use restraints	. Improve analysis of technology use restraints
. Education/Extension	. Support the public dissemination of environmental management practices
. Environmental plans	. Establish guidelines for local environmental planning . Subscribe to implementation incentives
OUTPUT-RELATED	
. Economics-Markets	. Advance the design of supply/demand management options . Subscribe to management of irregular export demands
. Residuals	. Establish monitoring capabilities . Improve analyses of residual control alternatives
SYSTEM RELATED	
. Institutional	. Improve government coordination . Enhance inter-media environmental coordination . Subscribe to more direct representation and input from agriculturalists in environmental planning . Support environmentally-related basic science research
. Climate/weather	. Support weather prediction improvements for environmental management . Support weather modification research for environmental management.

Source: Compiled by Development Planning and Research Associates from information received from the regional panels.

geneticists is that plant genetic research could provide an average annual rate of 1 percent increase in crop yields from the present to 2010--if this were a policy goal. In other words, a major portion of the needed growth could be achieved through continued germ plasm technology-plant genetics improvements.

Forwarding such a yield-increasing improvement is also an indirect environmental enhancing policy since the achievement of the output goals would otherwise require a more extensive cropping system with its attendant environmental effects. Additionally, plant genetic improvements directly offer significant environmental-enhancement potentials. The development of seeds and plants that are more pest and disease resistant and salt tolerant would directly aid producers in environmental management for the less frequent or lowered rates of agricultural chemical applications that they would allow would reduce the potential for adverse environmental effects.

Overall, then, the panels emphasized that policy goals should seek to sustain plant genetics-technology development and to establish more specific achievement goals for this input-related component of the crop production system.

b. Support agricultural chemicals improvements. A wide range of agricultural chemicals are used by crop producers--fertilizers, herbicides, insecticides, fungicides, nematicides, rodenticides, and others. Many of these chemicals are under review or have been restricted in their use for crop production for environmental impact reasons. Sometimes these restrictions have led to associated crop output losses, and have caused agriculturalists to question the benefit assessments underlying the EPA decisions. Additionally, the increasingly high research and development costs, extensive registration requirements for chemicals and the potential restrictive actions by EPA have inhibited prospective suppliers, lowered the rate of alternative chemicals produced, and caused higher costs of production for both the manufacturer and the crop producer.

In light of these conditions, the panels believed that specific policies should be instituted to support the improvement of agricultural chemicals. Such policies should provide incentives for development and production of effective, environmentally acceptable chemical components and formulations and should compensate for the present inhibiting policies that influence chemical research and production.

c. Foster equipment improvements. Equipment designed to be environmentally beneficial could significantly improve the environmental effects of farm tillage operations. At present, reduced-tillage systems are being utilized to a limited degree in most regions; however, until design improvements are made in planters and other equipment, such systems will not be fully utilized.

Improvements are also needed in land development equipment, in application equipment, in tillage equipment, and in harvesting equipment to cope with varied soil types, topographical conditions, and other cultural situations. Much of the emphasis toward large-scale operations has not led to improved environmental designs. Policies should be fostered that encourage the design and use of such equipment.

d. Support resource-use efficiency improvements. Like plant genetic improvements, resource-use efficiency improvements that lessen aggregate resource use can effectively maintain the productive capacity of the crop production system while improving its environmental effects. Obviously, too, such efficiencies can result in higher crop yields without an otherwise corresponding increase in resource use.

Although resource-use efficiencies are possible generally, the workshop panels were concerned most about two basic resources that are increasingly scarce in agriculture: water and energy. Particularly in the Western region, where agricultural water supplies are declining, a special need exists to improve irrigation water use efficiency. Improvements are being sought through new methods of water application, through changes in the timing and amounts of water application, through the recycling of irrigation run-off water, and through other management practices. A further emphasis is needed to improve water use efficiency in irrigated agriculture generally. Water will become increasingly critical in the future, and the growth potential of the crop production subsector is importantly limited by the capacity of the irrigated portion of that subsector.

Policy concerns should seek also to intensify the energy efficiency of the crop production subsector's production, harvest, and assembly functions. Furthermore, indirectly, via its major inputs--fertilizer, agricultural chemicals, irrigation water--additional energy efficiency improvements are possible for the crop production system. In both situations, however, the crop production subsector relies basically upon external sources to provide the technology developments which the subsector utilizes as inputs. There is a need, then, for policy directives and actions that can act as catalysts for such potential resource-use efficiency improvements.

2. Aggregate Resource Use

The panels were emphatic in their belief that policy concerns should be focused upon the necessity to maintain adequate production resources in the face of both dwindling supplies and competition for those from competing sectors of the nation's economy. Of paramount concern should be policies that address the supply of agricultural land, water, energy, and finances. The reasons for the concern are implicit in the dynamics of the crop production sector: if greater yields are required to meet the 2010 levels, then either additional resources must be allocated or the anticipated resource base must be more intensively managed. Such concerns and their implicit policy needs are recognized below.

a. Subscribe to land uses more protective of agriculture. An obvious policy issue should be one that assures an adequate supply of arable cropland for the needs of 2010. The workshop participants anticipate an adequate land base to meet their regions' 2010 moderate growth scenario projections; however they believe that land would be a major limiting factor in some regions, especially in the Cornbelt/Lake States. Much of the expansion in cropland use is expected in the Southeastern, Great Plains and northwest portions of the Western regions. Also the Northeastern region has growth potential, but less so for the feed and food grain crops anticipated to be needed by 2010. Furthermore, although the Cornbelt/Lake States can expand significantly to meet moderate growth projections, the region can realize 2010 growth production levels only by using environmentally fragile land.

An obvious concern then should be to assure that land will not become limiting in the foreseeable future. Adding to the problem, too, is that prime farmland is being regularly diverted into non-agricultural uses, oftentimes irreversibly, so that even further pressure on the cropland base can be expected. Compositely, then, there is a policy concern regarding this resource: Land use policies must be more protective of agriculture. Appropriate policies can only be forwarded in the short-term future, for by 2010 additional prime farmland losses will be effectively irreversible.

b. Improve upon aggregate water uses. The Great Plains and the Western regions of this study are highly dependent on irrigation water for commercial crop production and in much of the Western region, irrigation water--either surface water or groundwater--is essential. In fact, these regions are limited more by their water resource availability than by their arable land base.

The Western region, in particular, is fully cognizant of its aggregate water supply (and its variability) and, therefore, also, of the attendant limits it places on growth in crop production. The Great Plains region primarily utilizes groundwater sources, but it, too, realizes that supplies are limited. Groundwater depletions are now partially offsetting the continuing expansion of irrigation systems into new areas.

As was discussed above, irrigation water-use efficiency improvements are one important type of development for policy action. Further, however, critical public decisions will soon be needed to allocate aggregate water supplies, surface and groundwater, in the U.S. The production potential of the crop production system is heavily tied to the water resource base.

c. Maintain energy supplies and forms. During 1973-74, all sectors of the economy became aware of their vulnerability to critical energy shortages. The crop production subsector was no exception. The role of energy in producing the nation's necessary food supply is self-evident, but equally critical is energy's role in food processing, transportation, and the supplying of farm inputs. Up to the point of harvest, perhaps, the most critical energy supplies and forms for crop production would be: the energy used for producing and transporting key inputs (seeds, fertilizer, agricultural chemicals), direct energy (mobile, fossil fuel) for farm equipment and transport, and the energy for irrigation systems (diesel, natural gas, electric). This listing could easily be expanded to most other sectors (e.g., replacement equipment, steel production, finance).

From the standpoint of the crop production system only and to the extent that it is a critical subsector, policies should be determined that would assure the maintenance of energy supplies and forms to the system and to its key related segments of the economy. In the absence of such policies, the growth needed to achieve the crop yields projected for 2010 may not be possible.

3. Agricultural Finance

The credit and financing needs of crop producers have expanded greatly in recent years as the size of operations have increased and their input-related costs have grown. New approaches are needed to assure that adequate agricultural credit and financing can be obtained, especially during short-term adverse periods by viable agricultural producers.

Improve agricultural credit and financing. Crop producers may be faced, at times, with either adverse weather or depressed markets, conditions which reduce their short-term cash flow and loan repayment capacity. All too frequently, however, producers cannot depend upon present institutions, either private or public, to provide financing terms that do not require prohibitive or re-financing at high-risk rates. Under such conditions, the terms of financing become additional factors leading to poor financial situations beyond the producer's control.

Programs are needed then, to improve agricultural credit and financing terms for crop producers (and other segments of agriculture) to assure the maintenance of viable enterprises. Such policy related actions should especially insure the availability of working capital during short-term adverse periods caused by external factors. Obviously the anticipated greater financing requirements of agriculture in 2010 make such programs increasingly necessary.

C. Management-Related Policy Concerns

The second main type of policy concerns involve those prospective developments or actions that will affect crop producers' management practices. The following specific management-related policy concerns are those identified by the workshop participants.

1. Technology Use Restraints

This category of policy issues reflects the frequent concern that in their responsible management of environmental controls, local, regional, or national regulatory bodies that affect agriculture's resource use may not always adequately recognize the necessary balance of interests between needed production-yield levels and extensive environmental controls. Of immediate importance is the necessity to establish policies that will assure the achieving of this balance of interests.

Improve analysis of technology use restraints. The crop production system's attempts to achieve the 2010 production levels will doubtless involve the use of sophisticated technologies that, in many cases, especially those involving agricultural fertilizers, herbicides, and insecticides, will not be free of negative environmental effects. To be sure, their unrestricted use will not be in the public's best interest, but the panels were concerned that in cases where conflicts between necessary yield levels and the controlling of environmental effects are noticeable, a thorough analysis of both the benefits and disadvantages of technology use restraints be mandated by applicable policies.

Crop producers have been faced with numerous restrictions or bans on the use of agricultural chemicals (mostly pesticides). Perhaps such restrictions have been indeed, warranted, but where acceptable alternatives are not available, doubts exist that adequate trade-off analyses have been performed and that the risks of using the restricted technology do outweigh the benefits of resource use, i.e., increased quantity and quality of product. (Oftentimes the risks are predominantly taken by those directly handling or using the compounds, not the final consumers. Hence, policy concerns should require public analyses of technology-use restraints to carefully determine that the public will be benefited rather than adversely affected by government actions rescinding the use of technology.

2. Education-Extension

As the crop production system utilizes increasingly more sophisticated techniques and equipment, measures should be taken to assure their proper and most effective use. Unless those measures include steps to educate producers adequately, the effects of such techniques and equipment will not be fully realized. Such educational activities should be encouraged by public policy.

Support the public dissemination of environmental management practices. A fundamental need toward the achievement of environmental goals in agriculture is an effective extension program to disseminate information and to educate producers in the use of improved techniques and management practices. Local community efforts, designed in part by agriculturalists themselves, are expected to be required in order to prepare site-specific recommendations of the best practices for individual producers.

A needed policy concern will involve the degree of support that will be required to provide an effective public dissemination of EPA's subsequent best management practices (BMP's) programs and related environmental guidelines for nonpoint sources of pollution. Much of this effort is related to the 208-NPS planning process, yet the agriculturists' felt their input into such plans has, thus far, oftentimes been meager.

3. Environmental Plans

This category of policy issues is reflective of the crop production system's increasing responsiveness to those concerns involving the environmental effects of agricultural production. The panels recognized that this responsiveness, as it becomes more marked, must be, in part, shaped by policies that recognize the need for local area planning input and individual producer requirements. Such local inputs should be more formally obtained.

a. Establish guidelines for local environmental planning. Like most major legislative mandates, environmental quality improvements will involve an iterative series of steps toward the achievement of the goals and objectives originally sought. Agricultural, nonpoint source pollution control will be particularly difficult to accomplish rapidly because of the sources innately dispersed, varied, and fugitive characteristics. Conceivably, the first-round efforts to establish state and area wide 208-NPS plans for federal review will involve numerous and, perhaps, unique environmental control plans that reflect the needs of local areas.

The panels considered as appropriate to such planning procedures a policy concern that would help establish guidelines for local environmental planning efforts that would reflect local concerns and be shaped, in part, by local crop producers and agricultural representatives.

b. Subscribe to implementation incentives. A concern of the panelists was that some environmental management options will entail significant costs to private producers without yielding equivalent benefits. In a net present value economic framework, some environmental options, however publically beneficial, may simply not be feasible for the private producer in the short term.

In those cases where the private costs of a needed environmental action are expected to exceed short term producer benefits, an implementation program with incentives would preferably be subscribed to as a policy by EPA. Under such terms, which are in the public's and the private operator's interests, then environmental management of NPS pollution is expected to progress favorably.

D. Output-Related Policy Concerns

The aggregate outputs of the crop production system often create external effects--in relation to existing supply-demand conditions--that may lead to needed policy actions. The following policy concerns reflect the major areas where improved output-related policies are most likely to be required.

1. Economics - Markets

This category of output-related policy concerns emphasizes the role that irregular product demand and supply play in the crop production system's effect upon the environment. Ideally, the system's environmental effects would be best addressed if the demands made upon the system and the supply responses were regular and dependable, for such would allow producers to realize the best economic balance between costs and benefits. To that end, the panels emphasized that policy issues should forward (a) the design of supply and demand management options and (b) the management of irregular export demands.

a. Advance the design of supply/demand management options. Improved environmental management will usually involve at least short-term cost increases for crop producers. Such costs, even though perhaps beneficial to the producer in the long-term, have often been avoided in the past simply because market instabilities and the uncertainty of the timely recovery of pollution control costs have created unacceptable capital risks.

Despite any efforts to compensate producers for improved environmental management, market instabilities will continue as a disruptive influence over management planning. Both supply-induced or demand-induced market disruptions will, categorically, produce associated and disruptive environmental effects because producers can less capably (economically) maintain environmental management practices. Therefore, while on the one hand, a policy concern germane to EPA would be to support the design of supply and demand management options that forward market stability, the agency's own concern with environmental quality control policies should recognize and seek to compensate for the detrimental influences that stem from such market instabilities as they affect individual producers.

b. Subscribe to management of irregular export demands. Under this study's high growth scenario projections, crop outputs will increase regionally from 13 to 20 percent over the moderate growth case. At these high levels, the environmental parameters assessed were generally predicted to fall from those predicted for the moderate growth levels. The principal reason for the potential additional growth was increased foreign demand.

A factor discussed and agreed to by the workshop participants was that such increased demand could be supplied better--economically and environmentally--if the increases were predictable, regular, and had a stable growth rate. If export demands are irregular and varied, then the effects of such demands are environmentally disruptive since, again, producers do not expect to benefit economically from environmental practices in the short-term.

For these reasons then, EPA does have a bonafide interest in the improved management of irregular export demands to the extent that it contributes to the agency's ability to affect improved environmental controls.

2. Residuals

The ultimate focus of this study is on improving the environmental effects of the crop production system. Residual pollutant controls are one method for accomplishing this goal. Crop production residual outputs can be managed and controlled; in fact, several control approaches are usually available to the individual producer.

In the process of achieving the desired pollution control, there are two main policy concerns related to residuals control that the study's panels emphasized: (1) establish monitoring capabilities and (2) improve analyses of residual control system alternatives.

a. Establish monitoring capabilities. Much uncertainty exists currently regarding the magnitude and the severity of the pollutants from the crop production system, *per se*, and their environmental consequences relative to the composite of pollutants from all sources that affect environmental receptors. These pollutant conditions often vary significantly by seasons within the year and from year-to-year. Environmental monitoring programs are needed to determine such conditions and the extent of pollution-level variabilities.

A concerted policy aimed at furthering such monitoring capabilities and programs could establish or verify the significance of the environmental effects contributed by the subsector. Also, and importantly, the degree of success of subsequent crop production environmental management practices could be appropriately monitored. Such monitoring data would further provide necessary input for determining any needed improvements in environmental management programs.

b. Improve analyses of residual control alternatives. Within the crop production system, several residual control options usually exist, and these options may often be site-specific. For example, in a hypothetical but realistic case, the control of pesticide run-off may be improved by: (1) reducing the rate of use, (2) improving the quality of the input, (3) using an integrated pest management option, (4) changing management practices (land development, tillage, time of application, method of application), and (5) adopting residual treatment practices (run-off retention, maintain barrier strips). The determination of the best practice or combination of practices to be adopted is potentially complex and specific to an individual producer due to varied soil, topographic, and other conditions. Thus, in effect, generalized analyses should only be used as guidelines for recommending residual control practices.

Because of the innate complexity of assessing and comparing various residual control options, certain policy guidelines are also appropriate to assure that adequate analyses will be performed before any prospective pollution controls were mandated. This policy concern is consistent with the panels' opinions that additional agricultural representation and input are desired in environmental planning.

E. System-Related Policy Concerns

This final set of policy concerns includes items that may affect more than one main component of the crop production system. In particular, the institutional-related concerns were regarded as highly important for environmental improvement. These concerns and prospective policy issues are, like many of the preceding concerns, related to underlying exogenous factors which characterize the need for the types of policies described here.

1. Institutional

In general, those policy concerns that the panels considered to be "institutional" rather directly point toward feasible policy issues that would affect the manner by which environmental quality controls are determined by local, state, and national agencies. The panels felt that too frequently such agencies are not cognizant of the goals of other responsible bodies or of the contributions that can be made by agricultural specialists and agricultural research toward the setting of these goals. The panels felt, in general, that policies should be ennunciated that would enable the crop production system to realize the benefits in potentially reduced environmental effects that such policy concerns would offer.

a. Improve government coordination. A sense of confusion currently exists concerning the respective roles of federal, state and local governments in environmental quality management. Eventually, compatible environmental management decisions will be necessary at all government levels if effective implementation actions can be realistically expected. Under present conditions, any level of government could supplement, by making more stringent, the controls instituted by other agencies. Improvement of the quality of government coordination is needed, and policy actions may be required to accomplish such improvement. Policies should be sought that encourage interagency cooperation and coordination in the defining of problems and the determination of feasible solutions to them.

b. Enhance inter-media environmental coordination. A growing concern within the crop production subsector that is tangentially related to the previous one involves multi-media environmental interactions. For example, environmental agencies frequently consider the soil medium as a final receptor for various municipal, industrial, and agricultural wastes. However, when these wastes are so disposed of, their residuals can affect the soil (e.g., heavy metals), water (e.g., pathogens), and the air (e.g., odors). Hence further environmental management coordination policies are needed which recognize the interrelationships which exist among the primary media.

c. Subscribe to more direct representation and input from agriculturalists in environmental planning. During the initial stages of 208-NPS and other environmental planning efforts, little direct involvement of and input from agricultural representatives was obtained. Although some exemplary 208-NPS plans have been developed, including some stemming from agriculturists' inputs, these planning processes have often incorporated too little agricultural input that recognizes the important tradeoff relationships among private vs. public benefits and private vs. public costs associated with NPS and other agricultural-related environmental management.

Ultimately, the crop production subsector expects to become a major participant in improved environmental management efforts because this subsector is the dominant agricultural-related source of pollution. At some stage in the planning process, a definite commitment should be made to solicit and obtain pertinent input from the crop production subsector's representatives. A policy subscribing to such representation and input is desired.

d. Support environmentally related basic science research. Within the institutional structure of the U.S., a fundamental policy concern should be the nation's general commitment to basic science research--its programs, its long-range plans, and its appropriations. Some specific technology development-input needs, plant genetics improvements, were previously stressed because of their direct applicability in crop production. However, other and perhaps equally germane advances in production and in environmental management could be made through basic science developments. For example, advances in biological nitrogen fixation sources have been made, yet these advances and their full implications are not adequately assessable. Another major promising basic science research area involves modifying the photosynthesis properties of plants to improve the plants' solar radiation use efficiency. Such advances could result in major increased crop production potentials.

The workshop participants generally agreed that a strong and full institutional commitment to basic science research is vital to the nation's long-term growth of agriculture and, especially, the crop production subsector. An added opinion was that a greater mission-orientation in some basic science research efforts would be desirable.

2. Climate and Weather

The panels, though recognizing the inherent difficulties in agriculture's attempts to control its natural resources in all forms, did believe that policies should be implemented that would seek to alleviate the chief difficulties that so consequential a resource as climate and weather can pose. Of primary concern among those feasible policies are those that involve weather prediction and weather modification research.

a. Support weather prediction improvements for environmental management. Many of the crop producers management practices are directly related to weather or anticipated weather conditions. The timing of pesticide applications for instance, is an especially critical concern because a run-off producing storm immedidately following the application will result in substantially more pesticide loss (and water receptor gain) than would a similar storm that occurred a few days later.

Improved weather predictions themselves (both short and long range) would then contribute to lessening the negative environmental effects of crop production. Such weather forecasts would be particularly beneficial to crop producers in the Cornbelt/Lake States and in the Great Plains where major storms are seasonally present during the crop growing periods.

Thus, as applicable, the workshop recommends that EPA consider policies toward the improvement of weather predictions that will be environmentally beneficial within the crop production system.

b. Support weather modification research for environmental management. Aside from improved weather prediction, *per se*, various research programs are in progress to induce weather modifications. In some instances, for example, severe storms may be reduced in their intensity. Such modifications are potentially desirable because of their consequent reduced environmental effects, e.g., less run-off and attendant soil, nutrient and pesticide losses.

Thus, again, where applicable, EPA should forward policies that support weather modification research that would be environmentally beneficial. Such programs are outside the control of the crop production subsector itself, yet the potential environmental advantage of weather modification developments are of considerable importance to that system's attempts to lessen its environmental effects.

SECTION IX

RESEARCH NEEDS

The third major type of external event that regularly affects the crop production system is research development. Research developments can affect the system's inputs, management practices, and outputs--both the quantity and quality of the crop, and its residual outputs. Furthermore, research developments may be germane either to related exogenous factors that affect the crop production system or to related government policy analyses. Thus, indirectly, research developments importantly affect the crop production system.

In the preceding two sections, Sections VII and VIII, some of the main exogenous factors and policy concerns related to crop production were presented and analyzed according to their crop production system relationships. The focus of this section is on the system's principal research needs and their relationships to the system itself.

A. Types of Research Needs 1/

Each regional panel enumerated and discussed those environmentally related research needs that the panel considered were most important to its region's crop production system. These needs were subsequently assessed and then categorized from a national perspective according to their main effect, by subject-area, on the crop production system as follows:

Input-Related

- Technology development
- Aggregate resource use
- Agricultural finance

Management-Related

- Technology use restraints
- Education/extension
- Environmental plans

Output-Related

- Economics-markets
- Residuals

System-Related

- Institutional
- Climate/weather

1/ These research needs are partially incorporated in existant federal legislation, e.g., PL 92-500, PL 95-217, and others. A further assessment is needed to determine the adequacy of such legislation.

One or more specific research needs were identified within each of these categories as summarized in Exhibit IX-1. Each of the research needs is described below by the subject-area categorization shown above. Furthermore, this categorization provides the structural framework that links many of the exogenous factors, policy concerns and research needs of the crop production system. (For a further discussion of the prospective linkages among these system-related variables, see Section VII-A, Conceptual Framework.)

B. Input-Related Research Needs

The regional panels identified a broad range of research needs involving the improvement of crop production inputs and the assessment of long term resource use patterns that will affect the regional crop production subsectors. The crop production system's ability to meet its projected 2010 production levels is highly dependent upon both improving the quality of its inputs and having an adequate resource base of land, water, energy and other fundamental resources. Through research, these needs can be met.

1. Technology Development

An obvious category of research needs concerns those that directly affect the resources used by individual producers and upon which the crop production system depends. The panels emphasized that research on seed and plant genetics, on new and improved chemical formulations for fertilizers and pesticides, on planting and tillage equipment, and on efficient soil, water, and energy use must be directed toward the realization of two goals--achieving higher yields at more efficient resource use rates and achieving practices that will decrease the potentially severe environmental effects of such increased production yields. The panels considered the following research needs to be the most significant and promising.

a. Advance germ plasm potentials. Continued research is needed to increase the yield potentials of seeds and plants while maintaining the nutritional value of the crops. Such improvements are important to attain the projected levels of output; they are additionally important, however, because of their contribution to environmental maintenance by lessening the need to crop additional, more environmentally fragile land.

Further research is needed, also, to improve the "growth properties" of seeds and plants by making them more salt tolerant and insect, disease, and drought resistant. Other stress-related properties could be developed. Such improvements will increase crop production levels and lessen the need for aggregate chemical applications with their consequent environmental effects.

Both insect resistant and disease resistant developments would directly assist in environmental quality management by lowering the reliance on and the expected use of agricultural chemicals. More drought resistant crops might permit the annual cropping of much currently used fallow-cropped land and

Exhibit IX-1. Summary of major research needs affecting the crop production system

Crop Production System Component and Subject Area	Research Needs
INPUT-RELATED	
. Technology development	. Advance germ plasm potentials
	. Develop and extend plant biological nitrogen fixing capabilities
	. Develop effective, environmentally-compatible agricultural chemicals
	. Develop environmentally-designed farm equipment
	. Design and develop more water efficient irrigation systems
	. Improve energy-use efficiencies in crop production
. Aggregate resource use	. Assess prospective long-term land use demands and design alternative land use plans
	. Assess prospective long-term water demands and design alternative water allocation plans
	. Assess prospective energy use demands and design alternative energy allocation plans
	. Develop alternative on-farm energy sources
. Agricultural finance	. Design and appraise alternative methods of agricultural financing
MANAGEMENT-RELATED	
. Technology use restraints	. Conduct improved cost-benefit analyses of proposed technology-use restraints
	. Conduct cost-benefit analyses of alternatives to simultaneously achieve crop output and environmental goals
. Education/extension	. Design education/extension plans for BMP implementation
	. Develop means for establishing improved site-specific best management practices
. Environmental plans	. Evaluate potential best management practices
	. Design and assess integrated pest management alternatives
	. Establish and assess preferred crop sequencing alternatives
	. Develop local BMP implementation plans compatible with NPS plans
	. Determine local needs for BMP's incentives
OUTPUT-RELATED	
. Economics-markets	. Conduct analyses of policy alternatives for improving supply/demand management
	. Assess crop output growth potential under alternative environmental management strategies
	. Assess alternatives for improving the management of irregular export demands
. Residuals	. Design and develop a residuals monitoring system
	. Assess the transport and fate of agricultural chemicals in the environment
	. Assess the incidence of soil erosion, and the transport and fate of associated sediment
	. Design and evaluate prospective residual control systems
SYSTEM-RELATED	
. Institutional	. Design methods and procedures for coordinating inter-governments environmental activities
	. Design mechanisms to assure that agricultural representation and input are included in applicable environmental planning
	. Analyze multi-media interactions of environmental controls and delineate appropriate coordination requirements
	. Develop plans to expand and enhance environmentally-related basic science research
. Climate/weather	. Examine methods for obtaining and utilizing improved weather predictions for environmental management
	. Evaluate potential weather modification techniques for environmental management

Source: Compiled by Development Planning and Research Associates from information received by the regional panels.

open up environmentally preferred, high-quality land in semi-arid regions. Improved salt tolerant plants will aid both in increasing yields and in improving the soil-water management options in arid environments, especially in the Western region.

b. Develop and extend plant biological nitrogen fixing capabilities. Recent research developments have shown that biological nitrogen fixation in non-legumes is technologically feasible. Further research is needed, however, to develop commercially feasible capabilities and to extend such biological nitrogen fixation to other various and potential crops.

Such a development is potentially a highly significant environmental quality management option. To the extent that plants are nitrogen self-sufficient, they will require less direct nitrogen application and their environmentally sensitive nitrogen sources could be effectively reduced.

c. Develop effective, environmentally compatible agricultural chemicals. Even though a major emphasis on integrated pest management systems must continue, i.e., the development of mechanical, biological and chemical alternatives, a continuing research need exists to develop improved agricultural chemicals. In many cases, such chemicals may still be required for adequate pest and other problem management though perhaps, at reduced rates or through fewer applications.

The focus of continuing agricultural chemicals research is clearly already on the development of environmentally compatible compounds. A companion goal, however, must be that these materials be effective in crop management. Both of these goals complicate the research task; however, the research community must intensify research efforts both in public institutions and in the private sector. (Similar research needs exist for improving fertilizer formulations, although these basic elements are naturally occurring and generally more environmentally compatible.)

d. Develop environmentally designed farm equipment. Some of the proposed best management practices for crop production depend significantly on improved farm equipment, e.g., no-till planters, before such practices are practicable. Hence, a clear and important research need is to design and develop such equipment.

Additionally, the past design objectives for much farm equipment used in production, harvest, or assembly functions did not focus on environmental factors; therefore, numerous environmentally related equipment improvements could be expected through such an increased research emphasis. The panelists particuarly expressed the need to tailor equipment design for various soil, topographic, and farm-type conditions.

Reduced-tillage cropping systems, including no-till, have, in general, been favorably accepted, but their consequent problems--unmanageable crop residue and an increase in insects, rodents, other pests and weeds--have inhibited some producers who have been reluctant to continue this type of tillage.

Such problems may be adequately managed with a comprehensive development of equipment designed to control those attendant problems. Thus far, these equipment needs have not been adequately researched.

e. Design and develop more water efficient irrigation systems. Continued growth in crop production will be highly dependent on irrigation water supplies--the most limiting input--in some regions, especially the Western. Where such limits exist, the foremost research need to achieve growth is to design and develop more water efficient irrigation systems. Improvements have been made in such efficiencies through spray, drip and trickle irrigation systems. However, further improvements are needed and are critical to the achievement of the production goals that were deemed feasible by the study's regional panels.

f. Improve energy-use efficiencies in crop production. Although the crop production system's present use of energy is but a minor part of the nation's overall use, the panels recognized that under 2010 conditions, the assuring of sufficient energy supplies for crop production growth can become critical. Thus, additional research is warranted to improve energy-use efficiencies in crop production.

Irrigation pumping and delivery systems and tractor-implement synchronization energy use improvements need to be assessed. Furthermore, such changes in management practices as from conventional tillage to reduced-tillage could significantly conserve energy use in crop production.

2. Aggregate Resource Use

The crop production system's regional panels recognized that under this study's projected growth scenarios for 2010, the aggregate resource needs for adequate crop production will be jeopardized by the competing demands of other sectors of the nation's expanding economy. Supplies of land, water, and energy can be sufficient only if adequate research is carried out to determine resource requirements, to establish national resource use priorities, and to efficiently employ the economically available resources. Encompassing research for the use of land, water, and energy as cited below was considered feasible by the panels.

a. Assess prospective long-term land use demands and design alternative land use plans. Previous sections of this study showed that the 111 million acres of Class I-III soils available in 1975 for conversion to cropland are theoretically adequate for the projected 2010 production levels. Two conditions affect this adequacy, however: (1) other national economic sectors will also compete for the use of this land and (2) part of the 111 million acres will be used to compensate for the presently utilized acreage that is being taken out of production by other land use programs. In effect, then, the potential cropland acreage will be less than the estimated 111 million acres.

An important research need, then, is to comprehensively assess current land use and prospective land use demands by all sectors of the economy. Too, further research is needed to design alternative land use plans that can illustrate how such alternatives would affect the economy in general and the crop production subsectors in particular. Such research will need to show the consequent potential environmental effects of such alternative land uses.

b. Assess prospective long-term water demands and design alternative water allocation plans. Economically available surface and ground water supplies of suitable quality for crop production are considered limited in the long-term by most agriculturists. Without alternate water sources, the growth level of irrigated crop production will also become limited (even with prospective irrigation water-use efficiency improvements).

While much optimism is shown for increasing irrigated crop output, research must assess and project all sources of water demand as a guide to prospective conflicts and additional water requirements. Additionally, for planning purposes, alternative water allocation plans should be designed and reviewed. Such research should seek to indicate (1) all alternative water supply constraints over the germane sectors of the nation's economy, (2) such constraints over the crop production subsectors' use patterns, and (3) the environmental effects resulting from each alternative use pattern.

c. Assess prospective energy use demands and design alternative energy use plans. Energy supplies are, of course, vital to the crop production system. Additional research is needed, however, to characterize and quantify projected energy requirements. Furthermore, in the presumed case of limited energy supplies, alternative energy use plans should be designed to assess their consequent production and environmental effects.

d. Develop alternative on-farm energy sources. The maintenance and growth of the crop production system could be partially enhanced through the production of on-farm energy sources. For example, on a regional or subregional basis, the potential exists for the development of solar, wind, and biomass energy sources. Additional research is needed to design, evaluate, and develop those alternative energy sources that are applicable for individual (or group) producer(s).

The potential for biomass energy sources has special implications for the crop production subsectors and the environment. If additional cropland is required to provide the resources for biomass energy, then this study's basic crop output projections and their environmental implications would need to be reassessed as a separate research need.

3. Agricultural Finance

In their consideration of input-related research needs, the panels were acutely aware of the potential severity of agricultural financing and of the incremental costs that may be associated with the crop production system's attempts to meet the production levels of 2010 while minimizing their environmental effects. Inadequate or unattractive financing methods may affect the system by inhibiting its growth over time or by preventing individual producers' from using marginally available financing to continue environmentally beneficial practices during periods of short-term production and marketing instabilities. The panels, consequently, recommended that research be devoted to assessing the disadvantages of present financing methods and to designing of preferred alternatives.

Design and appraise alternative methods of agricultural financing. Both the long-term capital requirements (for land, equipment, farm structures) and the production credit needs (for seed, fertilizer, pesticides, labor) of the crop production system and its representative operations have increased markedly. Environmental management practices will further intensify these agricultural financing needs and problems already being experienced by many producers.

Associated research needs are, first, to assess the adequacy of existing financial sources and their terms of credit, and, second, to design and appraise alternative methods of agricultural financing. Particularly important to the latter research need is the consideration of repayment provisions during short-term adverse periods, e.g., poor crop-yield years and depressed market periods. At such times, while the long-term viability of crop production enterprises may be good, they may well be jeopordized by short-term loan repayment demands. Improved methods of financing are generally already needed; environmental management requirements should therefore consider, also, the attendant financing needs to be faced by crop producers.

C. Management-Related Research Needs

The second type of research concerns involves those that consider improved or alternative crop production system management practices. Those discussed below were the chief research needs that the panels felt bear directly upon the design and implementation of improved management practices.

1. Technology Use Restraints

The panels, though appreciating the complexity of and demands made upon technology use restraint decisions, were concerned that such decisions have not always reflected the various individual problems that are consequent to the decisions. Generally speaking, the panels felt that research is needed to assure more rigorous cost-benefit analyses in technology restraint decisions and to determine the full range of alternative management practices that could be adopted to lessen the imposition of restraints over crop production system technologies.

a. Conduct improved cost-benefit analyses of proposed technology-use restraints. More comprehensively designed and carefully conducted cost-benefit analyses of proposed technology-use restraints in crop production were recommended by the study's panels. In some instances, e.g., the banning of selected agricultural chemicals, past government actions preventing the use of technology are not questioned as having perhaps adversely affected the public and the producers rather than having benefited either.

More rigorous and thorough assessments of both (1) the expected public and private benefits and (2) the expected public and private costs are appropriate for making such technology-use restraint decisions. A second research need should be the designing of a systematic methodology for determining the principles and standards that should govern the setting of environmental control restraints over technology use. Necessarily, early decisions determining such restraints were limited in nature as they addressed particular environmental problems; however, perhaps sufficient experience has now been gained to allow the development of holistic, integrative standards for such studies.

A third research need reflected the panels' feeling that because of the public interest and involvement in decisions regarding the determination and implementation of environmental quality controls, research should evaluate the methods and procedures utilized to promote such public involvement into such a technically complex and sophisticated area of concern.

b. Conduct cost-benefit analyses of alternatives to simultaneously achieve crop output and environmental goals. The preceding research need expressed a concern for better assessing the cost-benefit relationships pertaining to a specific component of technology, e.g., a particular pesticide. A broader type of cost-benefit analysis is implicitly required, also, in order to insure that the cumulative effect of such specific technology use restraints does not threaten the achievement potential of macro-level goals (e.g., both desired output levels and desired environmental quality). Because a risk exists that desired crop output levels cannot be achieved in the face of severe technology restraints, research should establish the feasibility of achieving the environmental goals through alternative management practices that would less disrupt crop production goals.

Expressed as a research need, appropriate macro-level studies should be conducted that establish as their goal the delineation and assessment of alternative means of simultaneously achieving crop output and environmental targets. Further, these assessments should include a comprehensive cost-benefit analysis for each alternative. Such analyses should show both the private and public crop production system's costs and benefits to help in selecting an optimum environmental strategy for the subsector.

2. Education/Extension

The specific regional concerns of each panel made obvious the belief that great care must be exercised to assure that management practices be adapted in a manner that allows their successful implementation. To the extent that such management practices will require informed producers for their acceptance and effective use, they must be adequately promulgated. Such practices, again to be affectively implemented, must be tailored to meet specific area and producer requirements.

a. Design education/extension plans for BMP implementation. The effective implementation of proposed best management practices in agriculture will require the adoption of educational and extension programs. Appropriate planning and explicit coordination among government agencies is needed if such programs are to be optimally effective.

Research should establish a comprehensive education and extension plan for the implementation of environmental best management practices. This plan should recognize the need for coordination among EPA, USDA and other government agencies at federal, state, and local government levels. Furthermore, the need for public funding of such programs should be recognized.

b. Develop means for establishing improved site-specific best management practices. A tendency in the early stages of agricultural-related environmental planning was to assume the general and widespread applicability of some management practices without an adequate regional-local data base. As a result, some concepts could be imposed in areas where they were untested. Further research into and for local adaptation refinements could result in more effective management practices.

For example, among the regional panels, the concept of reduced tillage cropping systems now has many varied meanings. Each region and areas within regions have had to experiment with variations in tillage, planting, and crop residue management practices to determine the best "reduced tillage systems" for the cropping conditions of their environments. The lesson learned is that many "best management practices" are not--in their details--universally applicable.

Hence, an important research need is to develop the means for establishing improved site-specific best management practices. Unless such capability exists for tailoring BMP's to local conditions, an unfavorable reception of proposed programs may occur even though the favorable concepts inherent in BMP's are more broadly valid.

3. Environmental Plans

This category of management related needs stems from the panels' concern that the implementation of environmental quality control standards and programs recognize the significantly varied needs among all regions and the areas within each. Local areas differ considerably in their cropping patterns and practices and programs seeking to institute environmentally beneficial BMP and NPS plans cannot be optimally effective unless they recognize such area differences as determinants of producer management behavior and response to needed programs.

a. Evaluate potential best management practices. In addition to developing the means discussed above to determine site-specific best management practices, a prior need is to more comprehensively evaluate those potential best management practices that can be regionally applicable. This type of research would help identify those critical regional factors that affect the environmental and economic viability of such practices.

Secondly, because many management practices can be alternative procedures for producers, improved research is needed to assess their varied and related cost-effectiveness. The research should assess their relative applicability among regions to assist producer's to make management decisions and to provide EPA with information basic to determining regional implementation and program needs.

b. Design and assess integrated pest management alternatives. Integrated pest management (IPM) designs combine chemical, mechanical and biological pest controls to effectively control pests and to maintain or enhance environmental quality. This design concept is widely accepted though its proven options are limited; thus, implementation of IPM systems will likely be delayed.

In this instance, research is needed to not only test options that are currently proposed, but to design and assess alternative IPM's. Such assessments should, again, include both environmental and economic (output) impacts.

c. Establish and assess preferred crop sequencing alternatives. Among the management practices options for pollution control over multiple crop seasons is the sequencing of crops. This practice can often be implemented readily. However, research is needed to establish and assess the preferred sequencing alternatives. Although the alternatives assessed would primarily be those that are environmentally preferred, such assessments should include analyses of the economic implications of each alternative.

d. Develop local BMP implementation plans compatible with NPS plans. An emphasis on the implementation of best management practices (BMP's) is anticipated by the crop production subsectors. If this emphasis develops, then local BMP implementation plans are desirable to assure that location-specific and site-specific environmental factors can be and are incorporated into planning efforts. Furthermore, such BMP plans should be compatible with the areas' 208-NPS plans. Any prospective conflicts between the proposed 208-NPS plans and the crop production BMP plans could be better resolved if research is forwarded that identifies those conflicts and seeks an environmentally beneficial compromise among them.

Planning assistance and financial aid are generally needed to accomplish such planning efforts. Volunteer efforts are supportive, but additional public commitments are important for the developing of viable plans on a timely basis, e.g., public interagency participation should be supported vs. voluntary.

e. Determine local needs for BMP incentives. The implementation of those best management practices may require private investments and operating costs in excess of private producer benefits, though the social (public and private) benefits resulting from the practices exceed their costs. In such cases, incentives to assure the adoption of the BMP's are reasonable.

Extensive research is needed in BMP planning to determine local needs for BMP incentives. Just as location-specific factors can significantly alter the details of a BMP plan, so too, can the costs of BMP implementation vary as do benefits, at the local level. The requisite incentives should consider these variable factors.

D. Output-Related Research Needs

Research needs identified by the panels that primarily involve crop production outputs--crops and residuals--are described next. The crops-related research needs are principally those involving aggregate market effects, whereas the residuals-related research needs primarily involve local area concerns.

1. Economics-Markets

Obviously, crop producers, operating as they must within an economic framework, are responsive to the market characteristics of agricultural demand. Irregular demand and market instabilities often preclude a producer's willingness to assume increased production costs for environmentally beneficial practices because the benefits of such cost increases may be postponed for an unacceptable period of time. Too, in time of favorable demand, producer's may be encouraged to unwisely abandon beneficial practices in order to take advantage of short-term high demand markets. Research is needed that will offer alternatives, e.g., including environmental restraints, to such producer behavior.

a. Conduct analyses of policy alternatives for improving supply/demand management. Irregular fluctuations in the levels of either the supplies of or the demands for crops are major determinants of market instabilities. Such instabilities unfavorably affect producers' environmental management decisions. Rapid changes in the supply-output levels are, also, environmentally disruptive. The attainment of more consistently balanced supply-demand growth would effectively contribute to improved environmental management.

Research is needed, then, to investigate, in a policy analysis framework, prospective policy alternatives for improving supply and demand management. Research capabilities for conducting such policy analyses are being advanced, and the environmental implications of policy choices related to supply-demand management are particularly important.

b. Assess crop output growth potential under alternative environmental management strategies. Just as alternative growth strategies within the crop production subsector would imply differential environmental effects, similarly, also, alternative environmental management strategies will imply differential crop output effects. Research is needed to assess EPA's proposed strategies in terms of their potential output effects.

Ideally, research will be conducted on various, alternative environmental management strategies so that improved choices between both environmental quality levels and output levels may be realized. Such research, i.e., improved cost-benefit analyses, was previously described as a management-related research need.

c. Assess alternatives for improving the management of irregular export demands. A subset of the general need to assess supply/demand management alternatives is the more specific research need to design and assess alternatives for export demand management. Typically export demands have fluctuated irregularly, and both the level and the uncertainty of the timing of these demands affect, oftentimes adversely, the environmental impacts of the crop production system.

2. Residuals

Although the panels felt that significant environmental impact research has been done, they were concerned that such has often been rather general and theoretical. As a consequence, the panels felt that more specific research is required to determine the real term effects of the crop production system's residuals on soil, water, and air. The research should be designed to examine the composition, transport, and fate of such residuals in order to facilitate the development of holistic residual treatment and crop production practices systems. The specific research needs are those desribed below.

a. Design and develop a residuals monitoring system. Although environmental monitoring systems and programs exist generally, the workshop participants anticipate an expanded need to design and develop a residuals monitoring system in major crop producing areas. Without an effective residuals monitoring system in such locations, there exists neither the capability to assess the specific environmental effects of crop production residuals nor the capability to measure the degree of improvement associated with environmental management practices. Monitoring capabilities are important, and further design and development efforts are needed, e.g., as partially included in PL 95-217.

b. Assess the transport and fate of agricultural chemicals in the environment. The crop production panels emphatically expressed the research need to monitor the transport by media of agricultural chemical and to assess the environmental consequences of that transport environment. Their emphasis stems from two main concerns. First, the adverse effects of agricultural chemicals are often assumed rather than empirically demonstrated. Second, data documenting the transport mechanisms and indicating the fate of agricultural chemicals in all environmental media are needed for a full understanding of their control.

The transport and fate of specific agricultural chemicals are affected by factors such as soils, topography, climate/weather, and cultural (management) practices. Allowances for such refinements in agricultural chemical restraints could potentially increase output without consequent environmental effects.

c. Assess the incidence of soil erosion and the transport and fate of associated sediment. Much research has been done to develop models to predict the rates of soil erosion and associated sediment delivery to water streams and other receptors under specific soil, topographic, rainfall, and cropping conditions. Further research is needed to monitor and measure the incidence of soil erosion in local environmental planning areas. Additionally, research is needed to better assess the transport and fate of sediment in such areas, e.g., as partially included in NPS-208 programs and in PL 95-217 legislation.

Composite aggregate soil movement-erosion research is critical in assessing soil quality and the effect of productivity on the soil medium. Sediment gains in water and the actual transport and fate of sediment are critical in assessing water quality and associated ecosystem impacts on the water medium. Improved monitoring and assessment of both concerns are desired.

d. Design and evaluate prospective residual control systems. Many of the preceding research needs involving direct pollution control methods were to be focused on the effects of individual BMP's and specific input quality improvements. A further research need is to design and assess combinations of individual practices and techniques. In other words, prospective residual control systems need to be designed and evaluated.

The composite pollution control effects of several low-cost environmental practices may be as effective as some higher cost individual practices, or several practices may be required to meet desired environmental quality management objectives. In such cases, a more aggregative research approach is needed.

E. System-Related Research Needs

This final set of research needs reflects those concerns that could affect more than one of the major crop production system components. Two broad areas of research needs are institutional and climate/weather.

1. Institutional

The four major research need categories described below were those that the panels believed were essential to the development of adequate environmental enhancement programs. Two are concerned with the designing of adequate coordination procedure to assure a proper integration of diverse programs and to allow for adequate agricultural specialist inputs. Two are concerned with the development of sufficient basic research to allow such integration.

a. Design methods and procedures for coordinating intergovernment environmental activities. An increasingly evident policy-related research need is to better coordinate federal, state, and local government agencies' environmental activities.

Under present government environmental procedures, agencies of any one level of government can provide supplemental, more-stringent, environmental controls. Such controls could result in redundant crop producer actions in environmental management. Hence, effective government coordination must precede the adoption of specific pollution control plans if responsive implementation is expected.

b. Design mechanisms to assure that agricultural representation and input are included in applicable environmental planning. Another policy-related research need is to design mechanisms that will assure the utilization of both the crop production system's representatives and their applicable data input in environmental planning processes affecting the crop production system. A fear exists that pollution control requirements will inadequately reflect the producers' perspectives and expertise in developing cropland management programs, e.g., again public supported vs. voluntary agricultural representation is proposed.

These various management alternatives may be individually or collectively utilized to efficiently attain not only the environmental, but, also, the output goals that are sought.

c. Analyze multi-media interactions of environmental controls and delineate appropriate coordination requirements. Environmental pollution controls are being institutionally mandated for all primary environmental media--water, soil and air. In some cases the pollution controls on one medium utilize another medium as the "final" receptor for captured residuals--presumably in an acceptable environmental manner. However, first, the "receptor" medium is necessarily affected, and second, additional media-interactions will occur naturally. Some of the media-interations resulting from existing pollution controls have affected the crop production system and further pollution control interactions are anticipated, e.g., land disposal of municipal sewage sludge.

Associated research needs should analyze the multi-media interactions of all environmental controls, and, further, delineate appropriate actions and coordination requirements to resolve potential environmental control conflicts. The environmental benefits to one primary medium should not result in offsetting environmental costs in another.

d. Develop plans to expand and enhance environmentally related basic science research. Among the top research needs expressed by the study's workshop was that renewed, major institutional support be given to basic science research. A common belief of the scientists was that many plant (and animal) improvements are possible and achievable within the study's planning period.

Many of these possible and prospective plant-related improvements would be environmentally enhancing, directly or indirectly. Among them are the development of improved insect and disease resistant plants, higher yielding plants, extended biological nitrogen fixing capabilities, and improved photosynthesis properties. Therefore, and in support of environmental pollution control, a key policy-related research need is to develop plans to expand and enhance environmentally related basic science research.

2. Weather-Climate

Although the panels recognized that weather prediction and control techniques are still relatively primitive, they believed that the overall advantages of such techniques in minimizing the environmental effects of crop production are so promising that research in such areas should be pursued. Most susceptible to research are those techniques for short term forecasting and area-specific weather control.

a. Examine methods for obtaining and utilizing improved weather predictions for environmental management. Crop producers could enhance their production system's environmental effects through the use of improved short and long range weather predictions. Such environmental enhancements would result, for example, from producers' improved time of the applications of agricultural chemicals to reduce potential run-off, and from producers' improved scheduling efforts for tillage and other management practices to minimize soil erosion and compaction.

Because of these favorable types of environmental implications, an EPA examination of prospective methods for obtaining and utilizing improved weather predictions in the crop production sector is encouraged. In the aggregate, such weather prediction improvements represent a potential environmental pollution control option.

b. Evaluate potential weather modification techniques for environmental management. Although weather is basically uncontrolled, on-going research suggests that some weather phenomena may be modifiable in the future. For example, some severe storms (including hail storms) may be reduced in their intensity through developing techniques. This type of weather modification would be beneficial to the crop producer and to the environment.

Because of its favorable environmental aspects, there is a rationale for EPA to also evaluate potential weather modification techniques and determine the merit of fostering such techniques in their environmental control programs. Because weather modification research is in an early stage of development, this evaluation task might require a continuing review.

APPENDIX A

WORKSHOP PROCEDURES

The evaluation workshop's panels determined, judgementally, the environmental implications of regional crop production trends. Their assessments primarily involved regional-panel analyses, though general workshop discussions were conducted to ascertain similarities and differences among the studies five regions--Northeastern, Southeastern, Cornbelt/Lake States, Great Plains, and Western.

A flow chart of the workshop procedures is presented in Exhibit A-1. A series of twelve tasks were completed in the sequence shown, and work forms were provided to guide and structure the analysis. Also, an agenda for the workshop, as shown in Exhibit A-2, was prepared so that the work elements would be completed in the time available.

The work forms that were provided were structured, yet the panels were free to delete, modify or add trends and environmental parameters. The panels were asked to complete their assessments as they felt appropriate for their own regions.

The designated chairman of each regional panel was responsible for recording the panel's assessment results and for presenting its findings at the general workshop proceedings.

Brief instructions for completing the work forms and sample work forms follow.

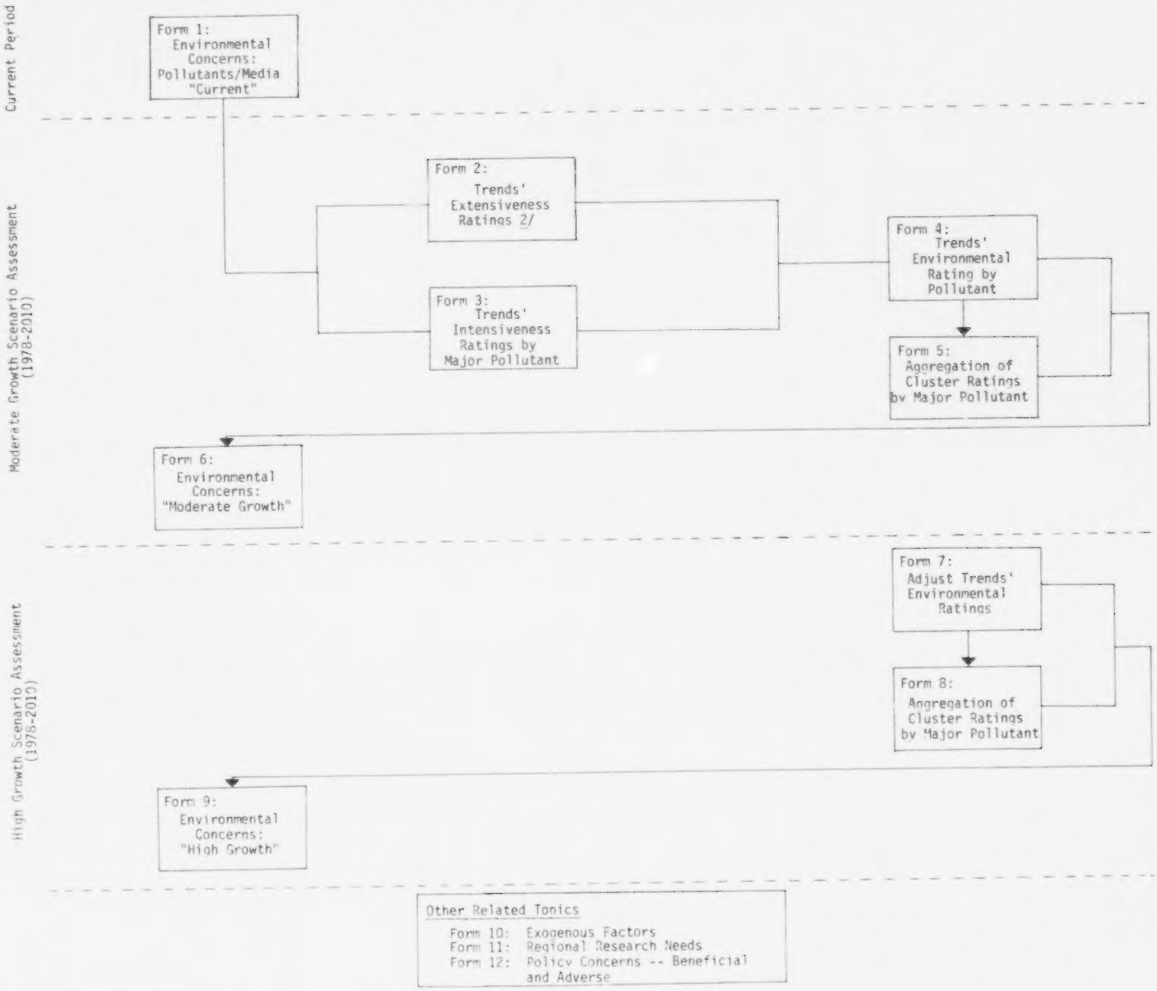
Instructions--Workshop Evaluation Forms

Form 1 -- Geographical differences in crop production activities and their resulting environmental implications are expected to occur during the next thirty years. Each panel will establish a regional ranking of environmental concerns according to the respective media at the current time period.

Form 2 -- Extensiveness of use rating from 1977-2010, will indicate the relative changes in the utilization of crop production activities over time. Ratings are to range from +1 (minor) to +5 (major).

Reproduced from best available copy.

Exhibit A-1. Flowchart of workshop procedures for the assessment of environmental implications of regional crop production trends[1/]


Current Period
Form 1: Environmental Concerns: Pollutants/Media "Current"
Moderate Growth Scenario Assessment (1978-2010)
Form 2: Trends' Extensiveness Ratings 2/
Form 3: Trends' Intensiveness Ratings by Major Pollutant
Form 4: Trends' Environmental Rating by Pollutant
Form 5: Aggregation of Cluster Ratings by Major Pollutant
Form 6: Environmental Concerns: "Moderate Growth"
High Growth Scenario Assessment (1978-2010)
Form 7: Adjust Trends' Environmental Ratings
Form 8: Aggregation of Cluster Ratings by Major Pollutant
Form 9: Environmental Concerns: "High Growth"
Other Related Topics
Form 10: Exogenous Factors
Form 11: Regional Research Needs
Form 12: Policy Concerns -- Beneficial and Adverse

[1/] Sample workshop forms, as referenced in the flowchart, are shown in Appendix A: The Workshop Procedures.

[2/] The trends' extensiveness of effects and the intensiveness of use ratings, and subsequent aggregation steps will involve all components of the crop production system: inputs, management practices and outputs.

Exhibit A-2

Assessment of the Environmental Implications of Regional Crop Production Trends

WORKSHOP AGENDA [1/]

Date/Session	Time	Activity
TUESDAY, FEB. 28	8:00 p.m.	. Arrive from Atlanta (Charter Bus)
		. Light buffet on arrival
Registration		. Registration and informal discussion
WEDNESDAY, MAR. 1	7:15 a.m.	. Group breakfast (designated dining area)
	8:00 a.m.	. Registration (late arrivals)
General Session I	8:30 a.m.	. Opening, George Bailey, EPA Introduction of Participants, Ray Seltzer, DPRA Welcome, Henry Garrens, Dean of Ag., U.of Ga. Workshop Setting/Purpose, Sam Unger, DPRA Crop Production System, Geneva Hammaker, DPRA Workshop Procedures, Gary Davis, DPRA
	10:00 a.m.	. Break
Panel Session I	10:20 a.m.	. Current Environmental Concerns (Form 1)
General Session II	11:20 a.m.	. Chairmen summarize region's assessment and discussion
	12:00 p.m.	. Group lunch (designated dining area)
General Session III	1:00 p.m.	. Moderate growth scenario and panel instructions
Panel Session II	1:20 p.m.	. Begin region's evaluations (Forms 2-5)
	3:00 p.m.	. Break
Panel Session III	3:20 p.m.	. Continue panel evaluations (Forms 2-5)
	5:00 p.m.	. Adjourn panel sessions
	6:00 p.m.	. Group dinner (designated area)
Panel Session IV	7:00 p.m.	. Complete panel evaluations (Forms 2-5)
		. Reassess environmental concerns (Form 6)
	9:00 p.m.	. Adjourn/Social Hour
THURSDAY, MAR. 2	7:15 a.m.	. Group breakfast
General Session IV	8:30 a.m.	. Chairmen summarize moderate-growth assessments
		. High growth scenario and instructions
	10:00 a.m.	. Break
Panel Session V	10:20 a.m.	. Complete high growth assessment (Forms 7-9)
	12:00 p.m.	. Group lunch
General Session V	1:00 p.m.	. Chairmen summarize high-growth assessment
		. Exogenous factors and instructions
Panel Session VI	2:00 p.m.	. Assess exogenous factors (Form 10)
	3:00 p.m.	. Break
Panel Session VII	3:20 p.m.	. Complete exogenous factors assessment (Form 10)
	4:00 p.m.	. Chairmen summarize regional assessments of exogenous factors
	5:00 p.m.	. Adjourn
	6:30 p.m.	. Dinner/Banquet (Bus Transport)
	9:30 p.m.	. Return to Center
FRIDAY, MAR. 3	7:15 a.m.	. Group breakfast
General Session VI	8:30 a.m.	. Final instructions/schedule
Panel Session VIII	8:45 a.m.	. Identify regional research needs (Form 11)
		. Identify policy concerns (Form 12)
	10:00 a.m.	. Break
General Session VII	10:20 a.m.	. Chairmen summarize regional research needs and policy concerns
		. Discussion
	11:15 a.m.	. Workshop Wrap-Up George Bailey, EPA Ray Seltzer, DPRA
	11:30 a.m.	. Adjourn
	11:45 a.m.	. Buffet lunch
	12:00 p.m.	. Air transport bus arrives for loading
	1:00 p.m.	. Bus leaves for Atlanta (Estimated arrival at 3:00 p.m.)

[1/] Held at the University of Georgia Center for Continuing Education, Athens, Georgia. Sponsored by the U.S. Environmental Protection Agency, Environmental Research Laboratory, Athens, Georgia, March 1-3, 1978. Under Contract by Development Planning and Research Associates, Inc., Manhattan, Kansas.

Form 3 -- Intensiveness of effect ratings indicate the relative environmental impact of each crop production input, management media, and output treatment activity. Ratings will provide an indication of the relative sediment, nutrient, pesticide, and other effects of these cropping activities. The ratings will range from -5 to +5, with (-) indicating an adverse effect and (+) indicating a beneficial effect.

Form 4 -- Environmental implications of crop production system trends will be established by subjectively weighing the extensiveness and intensive factors from forms 2 and 3. A rating (-5 to +5) will be assigned to the relative importance of the trend's sediment, nutrient, pesticide, and other effects. The primary purpose of this form is to aggregate the effects of several specific but related crop production activities.

Form 5 -- Environmental implications of the aggregate crop production activities changes will be assessed after considering the combined effects of inputs, management practices, and output-residual treatments upon sediment, nutrients, pesticides, and others (e.g., salinity). Ratings from Form 4 will be carried forward to Form 5 to provide a summary of the various crop production environmental effects. A final rating will indicate the net-aggregate regional environmental change expected between 1977 and 2010 (see Exhibit A-1).

Form 6 -- Ranking of environmental concerns to determine the importance of environmental trends in 2010. The ratings from Form 5 are to be converted into the same format as Form 1, and then establish any shifts in the importance of regional environmental concerns.

Form 7 -- Modification of moderate growth ratings by extensiveness of use and aggregate ratings. This form was designed to allow the modification of the moderate growth scenario at the crop production group level. (Note--this form was not used by the panelists due to time constraints.)

Form 8 -- High Growth: Regional ratings for the four environmental concerns should reflect changes from 1977 to 2010 under the high growth scenario.

Form 9 -- This form is essentially a repeat of Form 6 -- except the ratings are for the high (vs. moderate) growth scenario.

Form 10-- Exogenous issues are defined as items beyond or outside the control of the crop production subsector which may have an important effect upon the environmental implications of the crop production subsector. Resource members should attempt to eliminate disagreements on the importance of exogenous issues by assisting panel members in clarifying whether they are discussing the probability of the event occurring or the effect of the event. It is believed that the joint consideration of these two factors determines an important exogenous issue.

Form 11 - Research Needs -- Time will probably be a critical factor at this point; discussion should be kept within time constraints to assure a list of research needs.

Form 12 - Policy Concerns -- Again, time will dictate the amount of discussion; the list of regional policy concerns is important.

Region: ____________ Form 1

Time Period: Current

REGIONAL CROP PRODUCTION SUBSECTOR'S ENVIRONMENTAL CONCERNS

I. Rank of Environmental Concerns by Medium

	Water		Soil		Air	
Environmental Concern 1/	Effect	Rank	Effect	Rank	Effect	Rank
Sediment	Sediment Gain	☐	Soil Loss	☐	Dust/Particulates	☐
Nutrients	Nutrient Gain	☐	Nutrient Loss	☐	Gaseous, e.g., ammonia	☐
Pesticides	Pesticide Gain	☐	Pesticide Loss	☐	Drift	☐
Salts	Salinity	☐	Salt Concentration	☐	Dust-Salt Fraction	☐
Other	Other		Other		Other	
____	____	☐	____	☐	____	☐
____	____	☐	____	☐	____	☐

II. Rank of Environmental Effects among Media

Rank Order	Medium	Effect
1	____	____
2	____	____
3	____	____
4	____	____
5	____	____

III. Rank of Each Medium's Aggregate Environmental Effects

Rank Order	Medium	Index
1	____	100
2	____	____
3	____	____

SAMPLE

1/ The general terms shown are used hereafter to represent all environmental media effects and pollutant concerns.

Region: ____________

Growth Scenario: Moderate

Form 2

Page 1 of 7

TREND ASSESSMENT--EXTENSIVENESS OF USE

Production Variable	National Ratings 1976	National Ratings 1985	National Ratings 2010	Regional Ratings (1978) */ 1977	Regional Ratings (1978) */ 1985	Regional Ratings (1978) */ 2010	Comments or Remarks
	(from 1977 Workshop)						
I. INPUTS							
A. Quantity Utilized							
1. Additional land for cropland	4	4	5				
2. Nutrients	3	4	5				
3. Pesticides	3	4	4				
4. Water for irrigation	na	na	na				
5. Seeds & plants	na	na	na				
6. Other (e.g. equipment)	na	na	na				
B. Quality							
1. Cropland							
a. change in composition of cropland acres	na	na	na				
b. shift between dryland & irrigated cropland	na	na	na				
2. Nutrients							
a. use of alternative sources	na	na	na				
b. new chemical formulations	na	na	na				
3. Pesticides							
a. new chemical formulations	3	4	5				
b. biological controls	1	1	2				

*/ Ratings: 1 (minor) to 5 (major)

SAMPLE

Region: ____________

Growth Scenario: Moderate

Form 3

Page 1 of 7

TREND ASSESSMENT--INTENSIVENESS OF USE

Production Variable	National Ratings 1976	Intensiveness of Effect Ratings*/				Comments or Remarks
		Sedi- ment	Nutri- ents	Pesti- cides	Salts/ Other	
I. INPUTS						
A. Quantity Utilized (Assume Current Management)						
1. Additional land for cropland	-2					
2. Nutrients	na					
3. Pesticides	na					
4. Water for irrigation	na					
5. Seeds & plants	na					
6. Other (e.g. equipment)	na					
B. Quality						
1. Cropland						
a. change in composition of cropland acres	na					
b. shift between dryland and irrigated cropland	na					
2. Nutrients						
a. use of alternative sources	na					
b. new chemical formulations	na					
3. Pesticides						
a. new chemical formulations	+2					
b. biological controls	+3					

*/ Ratings: 1 (minor) to 5 (major) + or -

SAMPLE

Form 4

Page 1 of 7

REGIONAL AGGREGATION OF CROP PRODUCTION TRENDS AND THEIR ENVIRONMENTAL RATINGS

Region: ____________ Time Period: 2010 Growth Scenario: Moderate

Variables	Extensiveness Rating (2010)	Intensiveness of Effect Ratings				Overall Trend Rating */			
		Sedi-ment	Nutri-ents	Pesti-cides	Salts/ Other	Sediment	Nutrient	Pes-ticides	Salts & Other
I. INPUTS	(from Form 2)	---------(from Form 3)---------				-------(panel to rate at workshop)-----			
A. Quantity Utilized									
1. Additional land for cropland	___	___	___	___	___	☐	☐	☐	☐
2. Nutrients	___	___	___	___	___	☐	☐	☐	☐
3. Pesticides	___	___	___	___	___	☐	☐	☐	☐
4. Water for irrigation	___	___	___	___	___	☐	☐	☐	☐
5. Seeds & plants	___	___	___	___	___	☐	☐	☐	☐
6. Other (e.g. equipment)	___	___	___	___	___	☐	☐	☐	☐
B. Quality									
1. Cropland						☐	☐	☐	☐
a. change in composition of cropland acres	___	___	___	___	___				
b. Shift between dryland and irrigated cropland	___	___	___	___	___				
2. Nutrients						☐	☐	☐	☐
a. use of alternative sources	___	___	___	___	___				
b. new chemical formulations	___	___	___	___	___				
3. Pesticides						☐	☐	☐	☐
a. new chemical formulations	___	___	___	___	___				
b. biological controls	___	___	___	___	___				

*/ Ratings: 1 (minor) to 5 (major), + or -

SAMPLE

Form 5

ENVIRONMENTAL IMPLICATIONS OF CROP PRODUCTION ACTIVITIES

Region: ____________ Time Period 2010 ____________ Growth Scenario: Moderate

	Ratings of Environmental Concerns			
Cropland Variable	Sediment	Nutrients	Pesticides	Salts & Other
Inputs				
A. Quantity Utilized				
1. Land (cropland acres)	___	___	___	___
2. Nutrients	___	___	___	___
3. Pesticides	___	___	___	___
4. Water for irrigation	___	___	___	___
5. Seeds and plants	___	___	___	___
6. Other (e.g. equipment)	___	___	___	___
B. Quality				
1. Land	___	___	___	___
2. Nutrients	___	___	___	___
3. Pesticides	___	___	___	___
4. Water for irrigation	___	___	___	___
5. Seeds and plants	___	___	___	___
6. Other	___	___	___	___
Management				
A. Multi-season Management				
1. Land development	___	___	___	___
2. Crop Sequencing	___	___	___	___
B. Crop Season Management				
1. Crop planting practices	___	___	___	___
2. Crop and field monitoring practices	___	___	___	___
3. Crop fertilization practices	___	___	___	___
4. Pest control practices	___	___	___	___
5. Water application practices	___	___	___	___
C. Non-crop Season Management				
1. Crop residue control practices	___	___	___	___
2. Soil protection practices	___	___	___	___
3. Moisture control practices	___	___	___	___
4. Pre-plant fertilization practices	___	___	___	___
5. Pre-plant fertilization practices	___	___	___	___
Outputs - Residuals				
A. Residuals Control				
1. Pollutant treatments	___	___	___	___
2. Other treatments	___	___	___	___
Aggregate environmental change (net)	☐	☐	☐	☐

SAMPLE

Form 6

REGIONAL CROP PRODUCTION SUBSECTOR'S ENVIRONMENTAL CONCERNS

Region: ________ Time Period: 2010 Growth Scenario: Moderate

I. Rank of Environmental Concerns by Medium

	Current Rank (from Form 1)	Moderate Growth Scenario Rank
Water		
Sediment Gain	☐	☐
Nutrient Gain	☐	☐
Pesticide Gain	☐	☐
Salinity	☐	☐
Other ________	☐	☐
Soil		
Soil Loss	☐	☐
Nutrient Loss	☐	☐
Pesticide Loss	☐	☐
Salt Concentration	☐	☐
Other ________	☐	☐
Air		
Dust/Particles	☐	☐
Gaseous, e.g., ammonia	☐	☐
Drift	☐	☐
Dust-Salt Fraction	☐	☐
Other ________	☐	☐

II. Rank of Environmental Effects among Media

	Current		High Growth Scenario	
Rank Order	Medium	Effect	Medium	Effect
1				
2				
3				
4				
5				

III. Rank of Each Medium's Aggregate Environmental Effects

	Current		High Growth Scenario	
Rank Order	Medium	Index	Medium	Index
1		100		100
2				
3				

SAMPLE

Form 7

Page 1 of 7

AGGREGATING CROP PRODUCTION TRENDS AND THEIR ENVIRONMENTAL RATINGS

Region: ______________ Time Period: 2010 Growth Scenario: High

Variables	Extensiveness Rating 2010	Overall Trend Ratings				Modified Extensiveness Rating 2010	Overall Trend Ratings */			
		Sediment	Nutrients	Pesticides	Salts/ Other		Sediment	Nutrient	Pesticides	Salts/ Other
I. INPUTS	(from Form 2)	-------(from Form 4)---------				----------(panel to rate at workshop)-----------				
A. Quantity Utilized										
1. Additional land for cropland	___	☐	☐	☐	☐	___	☐	☐	☐	☐
2. Nutrients	___	☐	☐	☐	☐	___	☐	☐	☐	☐
3. Pesticides	___	☐	☐	☐	☐	___	☐	☐	☐	☐
4. Water for irrigation	___	☐	☐	☐	☐	___	☐	☐	☐	☐
5. Seeds & plants	___	☐	☐	☐	☐	___	☐	☐	☐	☐
6. Other (e.g. equipment)	___	☐	☐	☐	☐	___	☐	☐	☐	☐
B. Quality										
1. Cropland	___	☐	☐	☐	☐	___	☐	☐	☐	☐
a. change in composition of cropland acres	___					___				
b. shift between dryland and irrigated cropland	___					___				
2. Nutrients	___	☐	☐	☐	☐	___	☐	☐	☐	☐
a. use of alternative sources	___					___				
b. new chemical formulations	___					___				

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*/ Ratings: 1 (minor) to 5 (major), + or -

SAMPLE

Form 8

ENVIRONMENTAL IMPLICATIONS OF CROP PRODUCTION ACTIVITIES

Region: ________ Time Period 2010 Growth Scenario: High

Cropland Variable	Ratings of Environmental Concerns			
	Sediment	Nutrients	Pesticides	Salts & Other
Inputs				
A. Quantity Utilized				
1. Land (cropland acres)				
2. Nutrients				
3. Pesticides				
4. Water for irrigation				
5. Seeds and plants				
6. Other (e.g. equipment)				
B. Quality				
1. Land				
2. Nutrients				
3. Pesticides				
4. Water for irrigation				
5. Seeds and plants				
6. Other				
Management				
A. Multi-season Management				
1. Land development				
2. Crop Sequencing				
B. Crop Season Management				
1. Crop planting practices				
2. Crop and field monitoring practices				
3. Crop fertilization practices				
4. Pest control practices				
5. Water application practices				
C. Non-crop Season Management				
1. Crop residue control practices				
2. Soil protection practices				
3. Moisture control practices				
4. Pre-plant fertilization practices				
5. Pre-plant fertilization practices				
Outputs - Residuals				
A. Residuals Control				
1. Pollutant treatments				
2. Other treatments				
Aggregate environmental change (net)	☐	☐	☐	☐

SAMPLE

Form 9

REGIONAL CROP PRODUCTION SUBSECTOR'S ENVIRONMENTAL CONCERNS

Region: ____________ Time Period: 2010 Growth Scenario: High

SAMPLE

I. Rank of Environmental Concerns by Medium

	Current Rank (from Form 1)	Moderate Growth Rank (from Form 6)	High Growth Scenario Rank
Water			
Sediment Gain	☐	☐	☐
Nutrient Gain	☐	☐	☐
Pesticide Gain	☐	☐	☐
Salinity	☐	☐	☐
Other ____________	☐	☐	☐
Soil			
Soil Loss	☐	☐	☐
Nutrient Loss	☐	☐	☐
Pesticide Loss	☐	☐	☐
Salt Concentration	☐	☐	☐
Other ____________	☐	☐	☐
Air			
Dust/Particles	☐	☐	☐
Gaseous; e.g., ammonia	☐	☐	☐
Drift	☐	☐	☐
Dust-Salt Fraction	☐	☐	☐
Other ____________	☐	☐	☐

II. Rank of Environmental Effects among Media

	Current		Moderate Growth		High Growth Scenario	
Rank Order	Medium	Effect	Medium	Effect	Medium	Effect
1						
2						
3						
4						
5						

III. Rank of Each Medium's Aggregate Environmental Effects

	Current		Moderate Growth		High Growth Scenario	
Rank Order	Medium	Index	Medium	Index	Medium	Index
1				100		100
2						
3						

Form 10

Page 1 of 2

RANKING OF EXOGENOUS ISSUES WITH ENVIRONMENTAL IMPLICATIONS FOR THE REGIONAL CROP PRODUCTION SUBSECTOR

I. Listing and ranking of the most important exogenous issues affecting the crop production subsector by 2010

	Rating of Importance (Check One) [1]				
Issues	1 (minor)	2	3 (moderate)	4	5 (major)
a. ____	___	___	___	___	___
b. ____	___	___	___	___	___
c. ____	___	___	___	___	___
d. ____	___	___	___	___	___
e. ____	___	___	___	___	___
f. ____	___	___	___	___	___
g. ____	___	___	___	___	___
h. ____	___	___	___	___	___
i. ____	___	___	___	___	___
j. ____	___	___	___	___	___
k. ____	___	___	___	___	___

SAMPLE

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[1] Discuss most important issues in more detail, see page 2 of Form 10

Form 11
Page 1 of 2

REGIONAL CROP PRODUCTION SUBSECTOR RESEARCH NEEDS

Region ____________________

List of Research Needs	Rating	Comments on Importance
I. Inputs		
II. Management		
III. Output-Residuals		

SAMPLE

Form 12
Page 1 of 2

REGIONAL CROP PRODUCTION SUBSECTOR POLICY CONCERNS

Region ____________________

List of Concerns

Important Factors and/or Issues

I. Inputs

II. Management

III. Output- Residuals

SAMPLE

APPENDIX B

REGIONAL DATA AND TREND DEFINITIONS

This appendix contains the workshop panels' detailed trend assessments of the extensiveness of use (E) ratings(from work form 2) and the intensiveness of effect (I) ratings (from work form 3). Five exhibits (B-1 to B-5) are included, one for each region, as follows:

I - Northeastern
II - Southeastern
III - Cornbelt/Lake States
IV - Great Plains
V - Western

These data were developed and utilized by the regional panels themselves as intermediate information for the assessments as were presented in Section VI: Crop Production Trends' Assessment--Nation and Regions of the text. In general, a multiplicative score was calculated as follows: (E) x (I) = Rating of trend, for each period and for each environmental effect. As shown in the text, these ratings were then converted to (+) or (-) 1 (minor) to 5 (major) overall trend effects.

The trends assessed in this study are generally known to crop production specialists and, therefore, detailed definitions of these trends were not required, per se. However, more explicit definitions are available both in this study's Volume I: Trend Identification and Evaluation, and in the report: Control of Water Pollution from Cropland. 1/ Additionally, brief definitions of the crop production subsector's trends, as delineated in the following exhibits, are presented next in relation to their crop production system component, i.e., inputs, management practices, and outputs (residual controls).

Input Use Trends

Trends in input use were further classified as either trends in the quantity utilized or trends in input quality. This distinction is critical because increases in the quantity of inputs used will normally result in

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1/ U.S. Department of Agriculture (ARS) and U.S. Environmental Protection Agency (ORD), Control of Water Pollution from Cropland (2 Volumes), June, 1976.

adverse environmental effects, whereas improved qualities of inputs may effect beneficial environmental changes. Without the considering of the quantity versus quality aspects of input use, the potential net environmental implications of input use trends may not have been discernible in this analysis.

The basic crop production system inputs assessed--both quantity and quality trends--were cropland acreages, nutrients, pesticides, seeds and plants, irrigation water, and equipment. Other inputs were added by the separate regional panels as they believed necessary, i.e., those input uses which are expected to have consequential environmental implications.

Various trends in input qualities potentially exist because of alternative quality attributes which may be controllable in the future. Cropland quality may be varied in the aggregate because of the relative composition of land classes under cultivation, and, also, the shifting of land from dryland to irrigated farming which changes the environmental implications. Nutrient input qualities and their associated environmental implications can vary by source, e.g., inorganic or organic, and by chemical formulation, e.g., slow release compounds.

Trends in pesticide quality include the introduction of new chemicals, plus the development of biological controls which may at least partially control pests in integrated pest management systems. The quality of water used in crop irrigation may have significant environmental implications, partially as related to its source--ground or surface, or as related to the potential use of more saline water sources in the future. Various potential advances appear plausible in the development of seeds and plants, including higher yielding varieties, more pest and drought resistant plants, and more salt tolerant plants. Additionally, alternative crops may be introduced or expanded in use over time within a region.

The regional panels assessed each of these basic input use (quantity and quality) trends in their regions for the current period and for the moderate and high growth 2010 periods. The specific extensiveness of use and intensiveness of effects ratings for the moderate growth case are as presented in the exhibits below for each region.

Management Practice Trends

Three classes of management practices were specified in this study: (1) multi-season management, (2) crop season management, (3) noncrop season management. These distinctions are useful for recognizing that the environmental effects of crop production occur throughout the year--with or without a growing crop. Also, some management practices, such as land development practices, result in a relatively permanent (multi-season) change in the crop production capabilities and the associated environmental implications of cropping regardless of the crop produced.

Multi-Season Management

Multi-season management refers to those crop producer activities which have production and environmental implications for more than a single crop season--usually several years. Two types of multi-season management are: (1) land development practices, and (2) crop sequence practices.

Land development practices fundamentally involve structural changes of the land features to enhance crop production and, at times, to improve the environmental effects of crop production. In general, such structural changes have long-term consequences. This grouping of practices includes: (a) terraces, (b) grass waterways, (c) land forming, (d) irrigation structures, and (e) windbreaks. Trend projections of their use-levels and of their environmental implications were assessed during the workshop.

Crop sequence practices are primarily crop rotation decisions which have multi-season (long-term) implications. Such decisions may alter the environmental effects of crop production at individual farm sites and throughout a production area or region. This group of practices includes: (a) mono-crop rotation, (b) no-meadow rotation, (c) sod-based rotation, (d) double cropping, and (e) relay cropping.

Crop Season Management

Management during the crop season refers to all crop production activities from the planting to the harvest of crops and is limited to those which will cause no major stress on the crop, *per se*. The types of crop season management include: (1) crop planting practices, (2) crop and field monitoring practices, (3) crop fertilization practices, (4) pest control practices, and (5) water application practices.

Various crop planting practices are employed by crop producers and each practice has both crop output and residuals output effects; consequently, each crop season management practice has environmental as well as crop output implications. However, after a crop is planted, the producer's concern is to provide the proper nutrients, pest controls, and moisture (if controllable) to produce a profitable crop. Environmental concerns are often secondary in importance; indeed, they may not be regarded as being controllable by the producer. Despite the apparent conflict between crop output and residuals control, important improvements in the method of agricultural chemicals applications, in the assessment of a given crop's needs (nutrients, pest control, diseases, water, etc.), and in the timing of treatments can lead to both beneficial production results and beneficial environmental effects.

Crop planting practices are those related to the placement of seeds or plants and to the associated tillage operations. Planting practices may have distinguishable environmental effects throughout the growing season (and possibly longer). The specific planting practices included in this analysis are: (a) no-till planting, (b) narrow row planting, (c) contour planting, and (d) strip cropping, including barrier rows. Other practices are used, e.g., straight-row planting, but these will be considered as "conventional" practices which are the basis for estimating changes in the intensiveness of effects for trend projections.

Crop and field monitoring practices are various means of determining the status of crop growing conditions, including the monitoring of pests, diseases, moisture levels, plant growth and soil fertility. As monitoring capabilities are improved and applied, the potential exists for the better matching of input use-levels and plant growth needs. For example, some insecticides may typically be applied as a preventive measure without sufficient evidence of significant insect infestation. Since with improved monitoring (scouting), the extent of the rate of insecticide use may be reduced, this practice has obvious environmental implications. Three monitoring practices included for the workshop assessment are: (a) surface scouting, (b) remote-sensing scouting, and (c) soil-plant anslysis.

Crop fertilization practices involve both the methods for and the timing of fertilizer applications. Fertilizers of different forms (granules, liquid, gaseous) may be applied on the soil surface (with or without incorporation) through various placement options (broadcast, side-banded, row-banded, side-dress). Further, varied equipment may be utilized (bulk spreaders--truck, floater, tractor/wagon; drill; liquid-spray, irrigation; aerial). Some applications of fertilizer are foliar rather than soil-surface applied. In addition, one or several fertilizer applications may be made during the growing season. Obviously, then, many combinations of fertilization techniques are possible. For purposes of this study, however, the focus is on the following general practices: (a) surface application (broadcast and banded), (b) aerial application, (c) foliar application, and (d) multiple application. The latter practice incorporates the time variable, that is, the fertilizer is applied at different times throughout the growing season to accomodate plant growth nutrient requirements.

Pest control practices include those practices which utilize agricultural chemicals (primarily, herbicides, insecticides, fungicides, and nematicides) to control pests in crop production. Like fertilizer application practices, pest control practices involve various methods of application. Alternative product forms and alternative application techniques also exist. Again, only a limited set of general practices will be assessed in this study: (a) surface applied-broadcast, (b) surface applied-banded, (c) aerial applied, and (d) dual fertilizer/pesticide applied.

The distinction between broadcast and banded surface application is primarily one that isolates the rate per acre of pesticide use. Banded rates are generally lower; however, some type of supplemental practice may be required for some pests, e.g., banded herbicide treatment of a row crop may require supplemental cultivation, a form of integrated pest control. The dual application of fertilizer and pesticides represents a practice that is economically efficient.

Water application practices involve alternative methods of crop irrigation during the crop season. Some specified practices also involve irrigation water-use efficiency. The specific water application practices identified for this study's assessment are: (a) furrow basins, (b) sprinklers, (c) water conserving-trickle, subirrigation, other, (d) recycling tailwater. These practices are expected to have distinguishable environmental implications, and the extent of use of each differs within and among regions.

Noncrop Season Management

Management in the noncrop season refers to all management practices applicable to cropland after the harvesting of one crop and before the planting of the next. During the noncrop season, the crop producer can more readily till the soil and perform crop-related, but usually not crop-constrained, management practices.

Several such practices are those related to: (1) crop residue control, (2) soil protection, (3) moisture control, (4) pre-plant fertilization, and (5) pre-plant pest control practices.

Within these groupings of practices, many varied management practices are being utilized by producers. In each case, there is a noncrop season environmental effect and, frequently, a carry-forward crop season environmental effect. For example, many reduced tillage practices which lessen runoff and erosion and conserve moisture in the noncrop season will also have similar effects during the crop season. Thus, noncrop season management practices may be particularly important in the overall development of improved environmental pollution controls.

In some crop production locations, because of the climate and weather, the major environmental effects may occur in the noncrop season. In such cases, the noncrop season management practices will likely be regarded as more environmentally important than those in the crop season.

Crop residue control practices are those alternative methods and the timing of them used to control the organic crop residues after harvest. Crop residues may or may not be a "problem" depending on the type of crop, the subsequent crop planting practice, and/or the annual variability in the magnitude of the crop residue. Specific crop residue control practices included are: (a) fall incorporation, (b) spring incorporation, (c) residue removal, and (d) residue burning.

Soil protection practices include those that are principally designed to provide a soil stabilizing effect during the noncrop season. Other desirable environmental effects may be associated with these practices, e.g., reduced runoff and erosion, and improved water conservation. The specific management practices included are: (a) reduced tillage, (b) cover crops, (c) contour tillage, and (d) chemical erosion control.

Moisture control practices during the noncrop season are primarily intended as a means of conserving moisture in the soil for subsequent crops, especially in semi-arid production areas where natural moisture is limited. The practices included in this cluster grouping are: (a) fallow cropping, (b) chemical tillage, e.g. weed control to conserve soil moisture, and (c) chemical evapotranspiration control.

Pre-plant fertilization practices refer to all methods and times of fertilizer application during the noncrop season. Such applications may be made without direct interference with the growing crop and may be readily incorporated in the soil. Obviously, however, no crop is immediately available to utilize the nutrients applied. Only two general practices are specified herein as follows: (a) fall applied, and (b) seed-bed applied, i.e., just prior to planting.

Pre-plant pest control practices refer to all noncrop season pest control measures which will enhance the production of the subsequent crop. These practices may be applicable for pests either during the noncrop season or they may be applied during the noncrop season as a preventive measure for the subsequent crop. Two general management practices under this grouping are: (a) noncrop season pesticide use, and (b) pre-emergent pesticide use.

This outline of management practices within the crop production system was extended by the workshop as applicable for the study's regions. However, only additional practices which have important environmental implications were of specific concern for this study.

Output (Residual Control) Trends

Residuals from crop production systems include sediment, nutrients, pesticides, salts, organics, pathogens, odors and airborne particulate matter. These residuals affect all primary environmental media, including:

- surface water (quality and supply),
- ground water (quality and supply),
- air (quality), and
- soil (composition and productivity).

The presence of many of the crop production system residuals does not necessarily represent an environmental hazard, since many ecosystems utilize natural or other sources of residuals (e.g., sediment, nutrients). In other words, many food chains are actually dependent upon residuals in the environmental media. However, if excessive quantities of residuals (including toxic substances) are discharged into an environmental medium, then the life-supporting ecosystems or other uses of that environmental media may be detrimentally affected.

Many of the preceding input use and management practice trends will effectively prevent or reduce the generation of selected crop production system residuals. Hence, such residuals may be adequately controlled via those trends. However, a remaining potential alternative is to more directly treat crop output residuals after they have been generated.

Two types of residual control trends were designated for the workshop's assessment: (1) pollutant treatment, and (2) other treatment. Specific controls within each category were assessed.

Pollutant treatments for nonpoint source crop output residuals are quite different than traditional point source types of controls. In this case, the pollutants are typically dispersed and fugitive; residual controls generally rquire extensive rather than intensive treatment concepts. The specific pollutant treatment options assessed by the panels were: (a) barrier strips, (b) retention ponds, (c) diversion dikes, and (d) chemical/mechanical treatments. Most characteristically, some farmland is required for these residual controls, which implies a cost in terms of foregone income from any cropland losses. Another general characteristic of these trends is that, while they prevent pollutant "gains" into one environmental medium, they still have not controlled the "losses" from the originating medium, i.e., the soil.

Other treatments considered to achieve residual control were (a) land-use restrictions, and (b) cropping restrictions. These restrictions are effectively preventive practices, but they fall outside of the categories of crop management practices previously described. In some instances, e.g., the farming of environmentally fragile lands, the potential environmental damages from crop production, even with best management practices, may simply exceed both the private and public crop output benefits. In such cases, more restrictive actions may be necessary to achieve environmental management goals. Concurrently, however, crop output goals may be affected.

The regional panels' assessments of these specific trends, and their selected additions or deletions, follow in Exhibits B-1 through B-5. The extensiveness of use ratings refer to the study's moderate growth scenario.

Exhibit B-1. Trend assessment ratings by crop production region, 1977 to 2010, moderate growth scenario, Northeastern Region (Region I)

Crop Production Variable (Trend)	Extensiveness of Use Rating 1/			Intensiveness of Effect Rating 2/		
	1977	1985	2010	Sediment	Nutrients	Pesticides
I. INPUTS						
A. Quantity Utilized						
1. Additional land for crops	4.5	4.5	5.0	+1	+1	+1
2. Nutrients	2.5	3.5	4.0	+1	-2	0
3. Pesticides	3.0	3.0	4.0	0	0	-1
4. Water for irrigation	0.5	0.5	1.0	0	-1	0
5. Seeds & plants	3.0	3.0	4.0	0	0	+1
6. Equipment	3.0	4.0	5.0	0	0	0
7. Lime	2.0	2.5	3.0	na	na	na
B. Quality						
1. Cropland						
a. change in composition of cropland acres	1.5	1.5	2.5	+2	+1	0
b. shift between dryland & irrigated cropland	na	na	na	na	na	na
2. Nutrients						
a. use of alternative sources	2.0	2.5	3.5	+2	-1	+1
b. new chemical formulations	1.0	2.0	2.5	0	+1	0
3. Pesticides						
a. new chemicals	2.5	3.0	4.0	0	0	+1
b. biological controls	1.0	1.0	2.0	0	0	+2
4. Water for irrigation						
a. use of ground water	.25	0.5	1.0	0	-1	0
b. use of surface water	.25	.25	1.0	0	-1	0
c. use of saline water	0	0	.25	0	-1	0
5. Seeds and Plants						
a. with increased yield potential	3.5	3.5	4.5	+1	+1	0
b. with pest resistance	4.0	4.0	5.0	0	0	+1
c. with drought resistance	1.0	1.0	2.0	0	0	0
d. with salt tolerance	0	0	1.0	na	na	na
e. shift to alternative crop	1.0	2.0	3.0	-1	+1	+1
f. symbiotic nitrogen fixation	na	na	na	na	na	na
II. MANAGEMENT						
A. Multi-Season Management						
1. Land development practices						
a. terraces	1.0	1.5	2.0	+4	+1	+2
b. grass waterways	2.0	2.0	3.0	+3	+1	+2
c. land forming	0	0.5	1.0	na	na	na
d. irrigation structures	0	0	0.5	na	na	na
e. windbreaks	na	na	na	na	na	na
2. Crop sequence practices						
a. mono-crop	2.0	2.5	3.0	-2	-1	-2
b. no-meadow rotation	3.0	3.0	3.0	-1	-1	-1
c. sod-based rotations	2.0	2.0	2.0	+1	0	0
d. double cropping	na	na	na	na	na	na
e. relay cropping	na	na	na	na	na	na

Continued . . .

1/ Extensiveness of use ratings are positive values ranging from 1 (minor) to 5 (major) which, in a series for 1977, 1985 and 2010, indicate the expected "trend" in each crop production variable. na = not assessed

2/ Intensiveness of effect ratings are either positive (beneficial) or negative (adverse) values ranging from 1 (minor) to 5 (major) for each of the principal crop production-related environmental concerns -- sediment, nutrients, pesticides, salts/other (if applicable). These ratings indicate the expected environmental-effects change from using this practice vs. conventional practices.

Exhibit B-1 (Continued)

Crop Production Variable (Trend)	Extensiveness of Use Rating 1/			Intensiveness of Effect Rating 2/		
	1977	1985	2010	Sediment	Nutrients	Pesticides
B. Crop Season Management						
1. Crop planning practices						
a. no-till planting	2.0	3.0	4.0	+4	-1	+2
b. narrow row planting	3.0	4.0	4.0	+1	0	0
c. contour planting	2.0	2.0	2.0	+2	0	+1
d. strip cropping	2.0	2.0	2.0	+3	0	+2
2. Crop & field monitoring practice						
a. surface scouting	1.0	2.0	3.0	0	0	+3
b. remote sensing scouting	1.0	1.0	2.0	na	na	na
c. soil-plant analysis	3.0	3.0	4.0	0	+3	0
3. Crop fertilization practices						
a. surface application	3.0	3.0	4.0	0	-1	0
b. aerial application	1.0	1.0	2.0	0	-1	0
c. foliar application	0	0.5	1.0	0	+1	0
d. multiple application	3.0	3.0	4.0	0	+1	0
4. Pest control practices						
a. surface applied	3.0	3.0	4.0	0	0	-1
b. surface applied (banded)	2.0	2.0	3.0	0	0	0
c. aerial applied	1.0	2.0	2.0	0	0	-2
d. dual fertilizer/pest.	2.0	2.0	3.0	0	0	0
e. integrated pest control	1.0	2.0	3.0	0	0	+5
5. Water application practices						
a. furrow basins	na	na	na	na	na	na
b. sprinklers	1.0	1.0	2.0	0	-1	0
c. water conserving	0	0.5	1.0	0	0	0
d. recycling tailwater	na	na	na	na	na	na
C. Non-Crop Season Management						
1. Crop residue control practices						
a. fall incorporation	2.0	2.0	2.0	-3	-3	0
b. spring incorporation	3.0	3.0	3.0	-1	-1	0
c. residue removal	1.0	1.0	1.0	na	na	na
d. residue burning	na	na	na	na	na	na
2. Soil protection practices						
a. reduced tillage	3.0	4.0	5.0	+3	0	0
b. cover crops	1.0	1.0	2.0	+3	+2	0
c. contour tillage	2.0	2.0	3.0	+3	0	0
d. chemical erosion control	na	na	na	na	na	na
3. Moisture control practices						
a. fallow cropping	na	na	na	na	na	na
b. chemical tillage	na	na	na	na	na	na
c. chemical evapotranspiration control	na	na	na	na	na	na
4. Pre-plant fertilization practices						
a. fall applied	2.0	2.0	1.0	0	-3	0
b. seed-bed applied	3.0	3.0	2.0	0	-1	0
5. Pre-plant pest control						
a. non-crop season	na	na	na	na	na	na
b. pre-emergent-pesticides	3.0	3.0	4.0	0	0	-1
III. OUTPUT						
A. Residual Control						
1. Pollutant treatment						
a. barrier strips	1.0	1.0	2.0	+3	+1	+1
b. retention ponds	0	0	1.0	+4	0	0
c. diversion dikes	1.0	1.0	2.0	+3	+1	+1
d. chemical/mechanical	na	na	na	+5	+5	+5
2. Other treatments						
a. land-use restrictions	0.5	0.5	1.0	+4	+4	+4
b. cropping restrictions	0	0	1.0	+4	+4	+4

Exhibit B-2 . Trend assessment ratings by crop production region, 1977 to 2010, moderate growth scenario, Southeastern Region (Region II)

	Extensiveness of Use Rating 1/			Intensiveness of Effect Rating 2/		
Crop Production Variable (Trend)	1977	1985	2010	Sediment	Nutrients	Pesticides
I. INPUTS						
A. Quantity Utilized						
1. Additional land for crops	2.0	3.0	4.0	-2	-2	-1
2. Nutrients	2.0	3.0	5.0	+1	-2	na
3. Pesticides	4.0	5.0	4.0	+1	+1	-2
4. Water for irrigation	1.0	2.0	4.0	-1	+1	-1
5. Seeds & plants	1.0	2.0	3.0	+1	+1	+1
6. Equipment	3.0	4.0	4.0	+1	+1	+1
B. Quality						
1. Cropland						
a. change in composition of cropland acres	2.0	3.0	5.0	-2	-2	-1
b. shift between dryland & irrigated cropland	1.0	2.0	4.0	-1	+1	-1
2. Nutrients						
a. use of alternative sources	1.0	1.0	2.0	0	+2	0
b. new chemical formulations	2.0	2.0	3.0	0	+2	0
3. Pesticides						
a. new chemicals	2.0	3.0	5.0	0	0	+2
b. biological controls	1.0	1.0	2.0	0	0	+3
4. Water for irrigation						
a. use of ground water	1.0	2.0	4.0	-1	+1	-1
b. use of surface water	1.0	1.0	3.0	-1	+1	-1
c. use of saline water	na	na	na	na	na	na
5. Seeds and Plants						
a. with increased yield potential	4.0	4.0	5.0	+2	+3	+1
b. with pest resistance	2.0	2.0	3.0	+1	+1	+4
c. with drought resistance	2.0	2.0	3.0	+2	+2	+1
d. with salt tolerance	na	na	na	na	na	na
e. shift to alternative crop	2.0	3.0	4.0	-2	-1	-2
II. MANAGEMENT						
A. Multi-Season Management						
1. Land development practices						
a. terraces	1.0	1.0	2.0	+4	+4	+3
b. grass waterways	2.0	2.0	3.0	+4	+4	+3
c. land forming	2.0	2.0	3.0	+4	+4	+3
d. irrigation structures	1.0	1.0	3.0	+1	+1	+1
e. windbreaks	1.0	1.0	1.0	+2	+1	+1
f. drainage	2.0	2.0	3.0	-1	-1	-1
2. Crop sequence practices						
a. mono-crop	2.0	2.0	2.0	-2	-2	-2
b. no-meadow rotation	4.0	4.0	4.0	-1	-1	-1
c. sod-based rotations	1.0	1.0	1.0	+2	+2	+1
d. double cropping	2.0	3.0	4.0	+2	+1	+1
e. relay cropping	1.0	1.0	2.0	+2	+1	+1

Continued . . .

1/ Extensiveness of use ratings are positive values ranging from 1 (minor) to 5 (major) which, in a series for 1977, 1985 and 2010, indicate the expected "trend" in each crop production variable.

2/ Intensiveness of effect ratings are either positive (beneficial) or negative (adverse) values ranging from 1 (minor) to 5 (major) for each of the principal crop production-related environmental concerns -- sediment, nutrients, pesticides, salts/other (if applicable). These ratings indicate the expected environmental-effects change from using this practice vs. conventional practices.

Exhibit B- 2 (Continued)

Crop Production Variable (Trend)	Extensiveness of Use Rating 1/			Intensiveness of Effect Rating 2/		
	1977	1985	2010	Sedi-ment	Nut-rients	Pest-icides
B. Crop Season Management						
1. Crop planting practices						
a. no-till planting	2.0	2.0	3.0	+4	-1	-2
b. narrow row planting	2.0	3.0	4.0	+3	+2	+2
c. contour planting	3.0	3.0	3.0	+2	+2	+1
d. strip cropping	1.0	1.0	2.0	+3	+3	+2
e. reduced tillage	2.0	2.0	3.0	+1	+1	-1
2. Crop & field monitoring practice						
a. surface scouting	3.0	4.0	5.0	+1	+1	+4
b. remote sensing scouting	1.0	1.0	2.0	+1	+1	+1
c. soil-plant analysis	3.0	4.0	5.0	+1	+3	+1
3. Crop fertilization practices						
a. surface application	4.0	4.0	4.0	0	-2	0
b. aerial application	1.0	1.0	1.0	0	-1	0
c. foliar application	1.0	1.0	2.0	0	+1	0
d. multiple application	3.0	3.0	4.0	+1	+2	0
e. irrigation water	1.0	2.0	3.0	na	na	na
f. fertigation	na	na	na	+1	+2	0
4. Pest control practices						
a. surface applied	3.0	3.0	3.0	0	0	-2
b. surface applied (banded)	2.0	2.0	2.0	0	0	-1
c. aerial applied	3.0	4.0	3.0	0	0	-3
d. dual fertilizer/pest.	2.0	2.0	3.0	0	0	-1
e. integrated pest control	2.0	3.0	5.0	0	0	+4
f. irrigation applied	1.0	2.0	3.0	0	0	+1
5. Water application practices						
a. furrow basins	na	na	na	na	na	na
b. sprinklers	1.0	2.0	4.0	-1	+1	-1
c. water conserving	1.0	1.0	2.0	+1	+2	0
d. recycling tailwater	1.0	1.0	2.0	+1	+2	+1
C. Non-Crop Season Management						
1. Crop residue control practices						
a. fall incorporation	2.0	2.0	3.0	-1	-1	+1
b. spring incorporation	3.0	3.0	2.0	+1	+1	0
c. residue removal	2.0	2.0	2.0	-1	-1	0
d. residue burning	2.0	1.0	1.0	-1	-1	+1
2. Soil protection practices						
a. reduced tillage	3.0	4.0	5.0	+3	+2	-1
b. cover crops	1.0	2.0	2.0	+3	+3	0
c. contour tillage	3.0	3.0	3.0	+2	+1	0
d. chemical erosion control	1.0	1.0	1.0	na	na	na
3. Moisture control practices						
a. fallow cropping	na	na	na	na	na	na
b. chemical tillage	na	na	na	na	na	na
c. chemical evapotranspiration control	1.0	1.0	1.0	na	na	na
4. Pre-plant fertilization practices						
a. fall applied	1.0	1.0	2.0	-1	-3	0
b. seed-bed applied	4.0	4.0	4.0	0	0	0
5. Pre-plant pest control						
a. non-crop season	1.0	1.0	2.0	-1	-1	+1
b. pre-emergent pesticides	5.0	5.0	4.0	0	0	-2
III. OUTPUT						
A. Residuals Control						
1. Pollutant treatment						
a. barrier strips	1.0	1.0	2.0	+2	+1	+1
b. retention ponds	1.0	1.0	2.0	+3	+2	+2
c. diversion dikes	1.0	1.0	2.0	+2	+1	+1
d. chemical/mechanical	na	na	na	na	na	na
2. Other treatments						
a. land-use restrictions	1.0	1.0	2.0	+3	+3	+3
b. cropping restrictions	1.0	1.0	2.0	+2	+2	+2

Exhibit B-3 . Trend assessment ratings by crop production region, 1977 to 2010, moderate growth scenario, Cornbelt/Lake States Region (Region III)

Crop Production Variable (Trend)	Extensiveness of Use Rating 1/			Intensiveness of Effect Rating 2/		
	1977	1985	2010	Sediment	Nutrients	Pesticides
I. INPUTS						
A. Quantity Utilized						
1. Additional land for crops	4.0	5.0	5.0	-3	-2	-1
2. Nutrients	3.0	4.0	5.0	+1	-2	0
3. Pesticides	4.0	4.5	5.0	0	0	-2
4. Water for irrigation	1.0	2.0	3.5	0	-3	-1
5. Seeds & plants	na	na	na	na	na	na
6. Equipment	1.5	2.5	3.5	3	1.5	1
B. Quality						
1. Cropland						
a. change in composition of cropland acres	1.0	1.5	2.0	-3	-2	-3
b. shift between dryland & irrigated cropland	1.0	1.0	1.0	0	-2	-1
2. Nutrients						
a. use of alternative sources	1.0	2.0	3.0	1	2	0
b. new chemical formulations	2.0	2.5	3.0	0	2	0
3. Pesticides						
a. new chemicals	3.0	4.0	5.0	0	0	2
b. biological controls	1.0	1.0	3.0	0	0	4
4. Water for irrigation						
a. use of ground water	1.0	2.0	3.5	0	-3	-1
b. use of surface water	1.0	1.0	1.0	0	-3	-1
c. use of saline water	na	na	na	na	na	na
5. Seeds and Plants						
a. with increased yield potential	4.0	5.0	5.0	+1	1	0
b. with pest resistance	4.0	5.0	5.0	0	0	+3
c. with drought resistance	4.0	5.0	5.0	+1	+1	0
d. with salt tolerance	na	na	na	na	na	na
e. shift to alternative crop	1.0	1.0	1.0	0	0	0
f. non-symbiotic nitrogen fixation	1.0	1.0	2.0	0	4	0
II. MANAGEMENT						
A. Multi-Season Management						
1. Land development practices						
a. terraces	1.0	2.0	3.0	+4	+3	+3
b. grass waterways	3.0	4.0	4.5	+2	+2	+2
c. land forming	2.0	3.0	4.0	-1	-1	-1
d. irrigation structures	na	na	na	na	na	na
e. windbreaks	1.5	1.0	1.0	+1	0	0
f. drainage	3.0	4.0	4.5	+2	-1	0
2. Crop sequence practices						
a. mono-crop	2.0	1.5	1.0	-2	-2	-2
b. no-meadow rotation	4.0	4.0	4.5	-3	-1	-1
c. sod-based rotations	1.5	1.5	1.0	+3	+3	+2
d. double cropping	1.0	1.5	2.0	+1	+1	-1
e. relay cropping	1.0	1.0	1.5	+1	+1	-1

Continued . . .

1/ Extensiveness of use ratings are positive values ranging from 1 (minor) to 5 (major) which, in a series for 1977, 1985 and 2010, indicate the expected "trend" in each crop production variable.

2/ Intensiveness of effect ratings are either positive (beneficial) or negative (adverse) values ranging from 1 (minor) to 5 (major) for each of the principal crop production-related environmental concerns -- sediment, nutrients, pesticides, salts/other (if applicable). These ratings indicate the expected environmental-effects change from using this practice vs. conventional practices.

Exhibit B-3 (Continued)

Crop Production Variable (Trend)	Extensiveness of Use Rating 1/			Intensiveness of Effect Rating 2/		
	1977	1985	2010	Sedi-ment	Nut-rients	Pest-icides
B. Crop Season Management						
1. Crop planting practices						
a. no-till planting	1.0	2.0	3.0	+5	+1.5	-1
b. narrow row planting	3.0	4.0	5.0	+1	+.5	-.5
c. contour planting	2.0	2.0	1.5	+2	+1	+.5
d. strip cropping	1.5	1.5	1.0	+4	+2	+1
2. Crop & field monitoring practice						
a. surface scouting	1.0	3.0	4.0	0	0	+2
b. remote sensing scouting	1.0	2.0	3.0	0	0	+1
c. soil-plant analysis	3.0	4.0	5.0	0	+3	+1
d. environmental monitoring	1.0	3.0	4.0	+2	+1	+1
3. Crop fertilization practices						
a. surface application	5.0	5.0	5.0	0	0	0
b. aerial application	1.0	1.5	2.0	+.5	0	0
c. foliar application	1.0	1.0	2.0	0	0	0
d. multiple application	3.0	3.0	3.0	0	+1	0
4. Pest control practices						
a. surface applied						
- herbicides	4.0	5.0	5.0	0	0	-1
- insecticides	1.0	2.0	2.5	0	0	-1
b. surface applied (banded)						
- herbicides	2.0	1.5	1.0	0	0	+1
- insecticides	4.0	4.0	4.0	0	0	+1
c. aerial applied	3.0	4.0	4.0	0	0	-1.5
d. dual fertilizer/pest.	3.0	4.0	4.0	0	-1	-1
e. integrated pest control	3.0	3.5	4.0	0	0	+3
f. disease control	1.0	2.0	3.0	0	0	-1
5. Water application practices						
a. furrow basins	na	na	na	na	na	na
b. sprinklers	5.0	5.0	4.5	0	-2	-1
c. water conserving	1.0	1.0	1.5	0	0	0
d. recycling tailwater	1.0	1.0	1.5	0	+1	+1
C. Non-Crop Season Management						
1. Crop residue control practices						
a. fall incorporation	4.0	3.5	3.5	-3	-1.5	0
b. spring incorporation	3.0	3.0	2.0	-2	-1	0
c. residue removal	1.0	2.0	2.5	-2	-1	0
d. residue burning	na	na	na	na	na	na
2. Soil protection practices						
a. reduced tillage	2.0	4.0	4.5	+3	+1.5	-1
b. cover crops	1.0	2.0	2.0	+2	+2	0
c. contour tillage	2.0	3.0	4.0	+2	+1	+.5
d. chemical erosion control	na	na	na	na	na	na
3. Moisture control practices						
a. fallow cropping	na	na	na	na	na	na
b. chemical tillage	na	na	na	na	na	na
c. chemical evapotranspiration control	1.0	1.0	1.5	0	0	0
4. Pre-plant fertilization practices						
a. fall applied	2.5	3.0	3.5	0	-3	0
b.	5.0	4.5	4.5	0	-1	0
5. Pre-plant pest control						
a. non-crop season	2.0	2.0	2.0	0	0	-1
b. pre-emergent pesticides	na	na	na	na	na	na
III. OUTPUT						
A. Residuals Control						
1. Pollutant treatment						
a. barrier strips	1.0	2.0	2.0	+3	+1.5	+1.5
b. retention ponds	1.0	2.0	2.0	+3	+1	+1
c. diversion dikes	1.0	2.0	2.0	+2	+1	+1
d. chemical/mechanical	1.0	1.5	1.5	+1	+1	+1
2. Other treatments						
a. land-use restrictions	1.0	3.0	4.0	+3	+1	+1
b. crop restrictions	1.0	1.5	2.0	+3	+3	+3

Exhibit B-4. Trend assessment ratings by crop production region, 1977 to 2010, moderate growth scenario, Great Plains Region (Region IV)

Crop Production Variable (Trend)	Extensiveness of Use Rating 1/			Intensiveness of Effect Rating 2/			
	1977	1985	2010	Sediment	Nutrients	Pesticides	Salts/ Other
I. INPUTS							
A. Quantity Utilized							
1. Additional land for crops	4.0	4.1	4.6	-3	-2	-1	0
2. Nutrients	3.0	3.5	4.2	+1	-1	0	0
3. Pesticides	3.6	4.2	4.8	0	0	0.5	0
4. Water for irrigation	0.5	0.5	0.7	0	-0.1	0	-0.2
5. Seeds and plants	4.0	4.5	4.8	+1	+1	+0.5	0
B. Quality							
1. Cropland (quantity)	(0	0.1	0.6)				
a. change in composition of cropland acres	0	-0.1	-0.2	-3	-2	-1	0
b. shift between dryland and irrigated cropland	0	0	0.2	0	-0.1	0	-0.2
2. Nutrients							
a. use of alternative sources	0	0	0	0	0	0	0
b. new chemical formulations	0	0	0	0	0	0	0
c. new physical formulations	0	0.7	2.2	0	0.5	0	0
3. Pesticides							
a. new chemicals	2.0	3.0	4.0	0	0	0.1	0
b. biological controls	1.0	1.0	2.0	0	0	+2	0
4. Water for irrigation							
a. use of ground water	0	0	0.2	0	-0.1	0	-0.2
b. use of surface water	0	0	0	0	-0.1	0	-0.2
c. use of saline water	0	0	0	0	-0.1	0	-1
5. Seeds and plants							
a. with increased yield potential	4.0	4.1	4.8	0.5	0.5	0.5	0
b. with pest resistance	3.5	4.0	4.8	0.5	0.5	2	0
c. with drought resistance	1.0	1.0	2.0	0.5	0.5	0	0
d. with salt tolerance	1.0	1.0	1.2	0.5	0.5	0	0.5
e. shift to alternative crop	3.0	4.0	5.0	±0.2	±0.2	±0.2	0
II. MANAGEMENT							
A. Multi-Season Management							
1. Land development practices							
a. terraces	1.0	1.0	2.0	+4	4	4	0
b. grass waterways	1.0	1.0	2.0	4	4	4	0
c. land forming	1.0	1.0	2.0	1	1	1	0
d. irrigation structures	1.0	1.5	2.0	1	1	1	0
e. windbreaks	1.0	1.5	2.0	2	2	2	0
2. Crop sequence practices							
a. mono-crop							
- row	2.0	2.0	2.0	-2	-2	-2	0
- drilled	2.0	2.0	2.0	2	2	2	0
b. no-meadow rotation	4.0	4.0	4.0	-1	-1	-1	0
c. sod-based rotations	1.0	1.0	1.0	1	1	1	0
d. double cropping	0.1	0.1	0.2	2	2	1	0
e. relay cropping	0.1	0.1	0.2	2	2	1	0

Continued . . .

1/ Extensiveness of use ratings are positive values ranging from 1 (minor) to 5 (major) which, in a series for 1977, 1985 and 2010, indicate the expected "trend" in each crop production variable.

2/ Intensiveness of effect ratings are either positive (beneficial) or negative (adverse) values ranging from 1 (minor) to 5 (major) for each of the principal crop production-related environmental concerns -- sediment, nutrients, pesticides, salts/other (if applicable). These ratings indicate the expected environmental-effects change from using this practice vs. conventional practices.

Exhibit B- 4 (Continued)

Crop Production Variable (Trend)	Extensiveness of Use Rating 1/			Intensiveness of Effect Rating 2/			
	1977	1985	2010	Sediment	Nutrients	Pesticides	Salts/ Other
B. Crop Season Management							
1. Crop planting practices							
a. no-till planting	1.0	2.0	3.0	4	4	1	0
b. narrow row planting	3.0	4.0	5.0	1	1	0	0
c. contour planting	1.0	1.0	1.5	1	1	1	0
d. strip cropping	1.0	1.0	1.0	2	2	2	0
2. Crop & field monitoring pract.							
a. surface scouting	1.0	2.0	3.0	0.5	0.5	2	1
b. remote sensing scouting	0.5	3.0	5.0	0.5	0.5	2	1
c. soil-plant analysis	3.0	4.0	5.0	0.5	2	2	1
3. Crop fertilization practices							
a. surface application	4.5	4.5	4.8	0	0	0	0
b. aerial application	1.0	1.0	2.0	0	0	0	0
c. foliar application	0.1	0.1	0.2	0	0	0	0
d. multiple application	1.0	1.0	1.0	0	1	0	0
e. fertigation	1.0	2.0	2.5	0	2	0	0
4. Pest control practices							
a. surface applied	4.0	4.0	5.0	0	0	0	0
b. surface applied (banded)	2.0	1.0	1.0	0	0	2	0
c. aerial apllied	3.0	4.0	4.0	0	0	-1	0
d. dual fertilizer/pest.	3.0	4.0	4.0	0	0	0	0
e. integrated pest control	4.0	4.5	5.0	0	0	2	0
f. post-emergence pesticide	2.0	3.0	4.0	0	0	3	0
g. pre-emergence pesticide	4.0	3.0	2.0	0	0	0	0
5. Water application practice							
a. furrow basins	4.0	4.0	3.0	0	0	0	0
b. sprinklers	1.0	1.0	2.0	-2	-1	-1	0
c. water conserving	0	0	0.1	3	2	1	2
d. recycling tailwater	2.0	3.0	2.0	4	4	4	0
C. Non-Crop Season Management							
1. Crop residue control practices							
a. post-crop incorporation	0.1	0.1	0.1	0	0	0	0
b. pre-crop incorporation	4.5	4.5	4.5	1	1	0	0
c. residue removal	1.0	1.0	1.0	-1	-1	-1	0
d. residue burning	0	0	0	0	0	0	0
2. Soil protection practices							
a. reduced tillage	2.0	3.0	4.0	2	2	-1	0
b. cover crops	0	0	0				
c. contour tillage	1.0	1.0	1.5	1	1	1	0
d. chemical erosion control	0	0	0				
3. Moisture control practices							
a. fallow cropping	2.0	2.0	1.5	-2	-2	+1	-0.5
b. chemical tillage	0.1	1.0	2.0	3	3	-0.5	0
c. chemical evapotranspiration control	0	0	0.1	1	1	1	0
4. Pre-plant fertilization practices							
a. post-crop applied	1.5	2.0	2.5	0	0	0	0
b. pre-crop applied	3.5	3.0	2.5	0	0	0	0
5. Pre plant pest control							
a. non-crop season	0.5	0.5	1.0	0	0	0	0
b. pre-emergent-pesticide	4.0	3.0	2.0	0	0	0	0
III. OUTPUT							
A. Residuals Control							
1. Pollutant treatment							
a. barrier strips	1.0	1.2	1.5	2	2	2	0
b. retention pounds	0.1	0.2	0.5	2	1	2	0
c. diversion dikes	0.1	0.1	0.2	1	1	1	0
d. chemical/mechanical	0	0	0	0	0	0	0
2. Other treatment	0	0	0	0	0	0	0

Exhibit B- 5. Trend assessment ratings by crop production region, 1977 to 2010, moderate growth scenario, Western Region (Region V)

Crop Production Variable (Trend)	Extensiveness of Use Rating 1/			Intensiveness of Effect Rating 2/			
	1977	1985	2010	Sediment	Nutrients	Pesticides	Salts/ Other
I. INPUTS							
A. Quantity Utilized							
1. Additional land for crops	4.0	4.0	4.0	-3	-3	-2	-3
2. Nutrients	4.0	4.5	4.5	+1	-1	0	0
3. Pesticides	3.0	4.0	4.5	+2	+1	-1	0
4. Water for irrigation	3.0	3.5	4.5	-1	-1	-1	-1
5. Seeds and plants	5.0	5.0	5.0	+1	+1	0	0
6. Other	1.0	1.5	2.0	-1	0	0	-1
B. Quality							
1. Cropland							
a. change in composition of cropland acres	1.0	1.5	2.5	-2	-1	0	-1
b. shift between dryland and irrigated cropland	1.0	1.5	2.0	+1	-1	-1	-1
2. Nutrients							
a. use of alternative sources	1.0	1.0	2.0	+1	-1	0	-3
b. new chemical formulations	1.0	1.0	1.5	0	+1	0	0
3. Pesticides							
a. new chemicals	3.0	4.0	5.0	0	0	+2	0
b. biological controls	1.0	1.5	2.5	0	0	+3	0
4. Water for Irrigation							
a. use of ground water	3.5	3.0	2.5	+1	+1	0	+1
b. use of surface water	4.0	4.5	5.0	+1	+1	0	+1
c. use of saline water	0.0	0.5	1.0	0	0	0	0
5. Seeds and plants							
a. with increased yield potential	2.0	2.5	4.0	+2	+3	0	0
b. with pest resistance	1.0	1.5	3.0	+2	+2	+3	0
c. with drought resistance	1.0	1.0	1.5	+3	+3	+1	+1
d. with salt tolerance	2.0	2.5	4.0	0	0	0	+4
e. shift to alternative crop	1.0	1.0	2.0	-1	-1	-1	-1
f. cold tolerance	0	0.5	1.0	+1	+1	0	0
II. MANAGEMENT							
A. Multi-Season Management							
1. Land development practices							
a. terraces	1.0	1.0	2.0	+4	+2	+1	0
b. grass waterways	1.0	1.0	1.0	+4	+1	+1	0
c. land forming	2.0	2.5	4.0	+4	+2	+1	+3
d. irrigation structures	2.0	2.5	4.0	+3	+1	+1	+2
e. windbreaks	1.0	1.0	1.0	+2	0	0	0
f. soil profile modification	1.0	1.5	2.5	+2	+1	0	+2
2. Crop sequence practices							
a. mono-crop	2.0	2.0	2.0	-2	0	-2	0
b. no-meadow rotation	4.0	4.0	4.0	-1	0	0	0
c. sod-based rotations	1.0	1.0	1.0	+2	+1	+1	0
d. double cropping	2.0	2.5	3.0	-2	0	-1	-1
e. relay cropping	2.0	2.5	3.0	-2	0	-1	-1

continued . . .

1/ Extensiveness of use ratings are positive values ranging from 1 (minor) to 5 (major) which, in a series for 1977, 1985 and 2010, indicate the expected "trend" in each crop production variable.

2/ Intensiveness of effect ratings are either positive (beneficial) or negative (adverse) values ranging from 1 (minor) to 5 (major) for each of the principal crop production-related environmental concerns -- sediment, nutrients, pesticides, salts/other (if applicable). These ratings indicate the expected environmental-effects change from using this practice vs. conventional practices.

Exhibit B-5 (Continued)

Crop Production Variable (Trend)	Extensiveness of Use Rating 1/			Intensiveness of Effect Rating 2/			
	1977	1985	2010	Sediment	Nutrients	Pesticides	Salts/ Other
B. Crop Season Management							
1. Crop planting practices							
a. no-till planting	1.0	1.0	2.0	+4	+1	-2	0
b. narrow row planting	3.0	4.0	5.0	+1	+1	0	-1
c. contour planting	0.5	0.5	1.0	+2	+1	+1	+1
d. strip cropping	2.0	2.0	2.0	+2	+1	0	0
2. Crop and field monitoring pract.							
a. surface scouting	2.0	3.0	5.0	+2	+2	+4	+1
b. remote sensing scouting	1.0	1.0	2.0	+1	+1	+2	+2
c. soil-plant analysis	3.0	4.0	5.0	0	+4	+1	+2
3. Crop fertilization practices							
a. surface application							
- broadcast	4.0	3.0	2.0	0	-1	0	0
- banded	2.5	3.0	4.0	0	+1	0	0
b. aerial application	1.0	1.0	1.0	0	-1	0	0
c. foliar application	1.0	1.5	2.0	0	+1	0	0
d. multiple application	3.0	3.0	4.0	0	+3	0	0
e. irrigation water application	1.0	1.5	2.0	0	-1	0	0
4. Pest control practices							
a. surface applied	1.0	1.0	2.0	0	0	-1	0
b. surface applied (banded)	1.0	1.0	2.0	0	0	-1	0
c. aerial applied	3.0	4.0	4.0	0	0	-2	0
d. dual fertilizer/pest.	1.0	1.5	3.0	0	0	-1	0
e. integrated pest control	2.0	4.0	5.0	0	0	+3	0
5. Water application practice							
a. basins	0.5	0.5	1.0	+3	+1	+1	+2
b. sprinklers	2.0	2.5	3.0	+3	+2	0	+1
c. water conserving	0.5	0.5	1.0	+5	+3	+1	+1
d. recycling tailwater	2.0	3.0	2.0	+4	+2	+1	0
e. furrow	4.0	4.0	3.5	-2	-1	-1	0
C. Non-Crop Season Management							
1. Crop residue control practices							
a. fall incorporation	3.0	3.0	3.0	-1	+1	+1	0
b. spring incorporation	2.0	2.0	2.0	+1	+1	+1	0
c. residue removal	1.0	1.0	1.5	-2	-2	-1	0
d. residue burning	1.0	1.0	0.5	-3	-2	-1	0
2. Soil protection practices							
a. reduced tillage	2.0	3.0	4.0	+3	+2	+1	+1
b. cover crops	1.0	1.0	1.0	+3	+3	+1	0
c. contour tillage	0.5	0.5	1.0	+3	+2	+1	+1
d. chemical erosion control	0	0	0.5	+2	+1	+1	0
3. Moisture control practices							
a. fallow cropping	2.0	2.0	2.0	-2	0	0	0
b. chemical evapotranspiration control	0	0	1.0	+1	+1	0	+1
c. water harvesting	0.5	1.0	2.0	+2	+1	+1	+1
4. Pre-plant fertilization practices							
a. fall applied	0.5	0.5	0	0	-3	0	0
b. seed-bed applied	4.5	4.5	5.0	0	+1	0	0
5. Pre-plant pest control							
a. non-crop season	0	0	0	0	0	0	0
b. pre-emergent-pesticides	1.0	1.5	2.5	-1	+1	+1	0
III. OUTPUT							
A. Residuals Control							
1. Pollutant treatment							
a. barrier strips	0	0.5	1.0	+3	+2	+1	0
b. retention ponds	1.0	2.0	1.0	+4	+2	+1	0
c. chemical/mechanical	0.5	1.0	1.5	0	+1	+1	0
2. Other treatments							
a. land-use restrictions	0	0.5	2.0	+4	+2	+1	+3
b. cropping restrictions	0	0.5	1.0	+2	+1	+2	+1

APPENDIX C

REGIONAL DATA: CROP PRODUCTION SYSTEM

The assessment of environmental implications of regional crop production trends requires a knowledge and understanding of both natural factors (e.g., climate, soils, geographical features) and the crop production systems utilized in each region. Selected materials and information are summarized below which characterize each of the study's five regions: Northeastern, Southeastern, Cornbelt/Lake States, Great Plains, and Western, as illustrated by the map shown in Exhibit C-1.

First, data and information that are best presented on a national/regional basis are shown. Both similarities and differences among the regions are readily perceived from the national perspective. Second, region-specific data are presented for each region.

A. National/Regional Information

Maps showing various natural factors important for crop production are presented to provide an overall view of climatic and geographic factors in the U.S. and to show interregional and intraregional relationships (Exhibits C-2 to C-12).

1. Climate
    - Mean Annual Precipitation
    - Mean Annual Freeze-free Period
    - Mean Annual Wind Speed

2. Soil
    - General Pattern of Great Soil Groups

3. Geography
    - Principal Rivers and Drainage Basins

4. Management Practices
    - Contour Farming
    - Stripcropping and Terraces
    - Tillage Methods by Region
    - Tillage Method by Crop and Region

5. Output
    - Location of Cropland for Corn, Soybeans, Cotton and Wheat
    - Relative Potential Sediment Contribution to Watershed

Exhibit C-1. Five regional sectors utilized for analysis of environmental implications of crop production trends

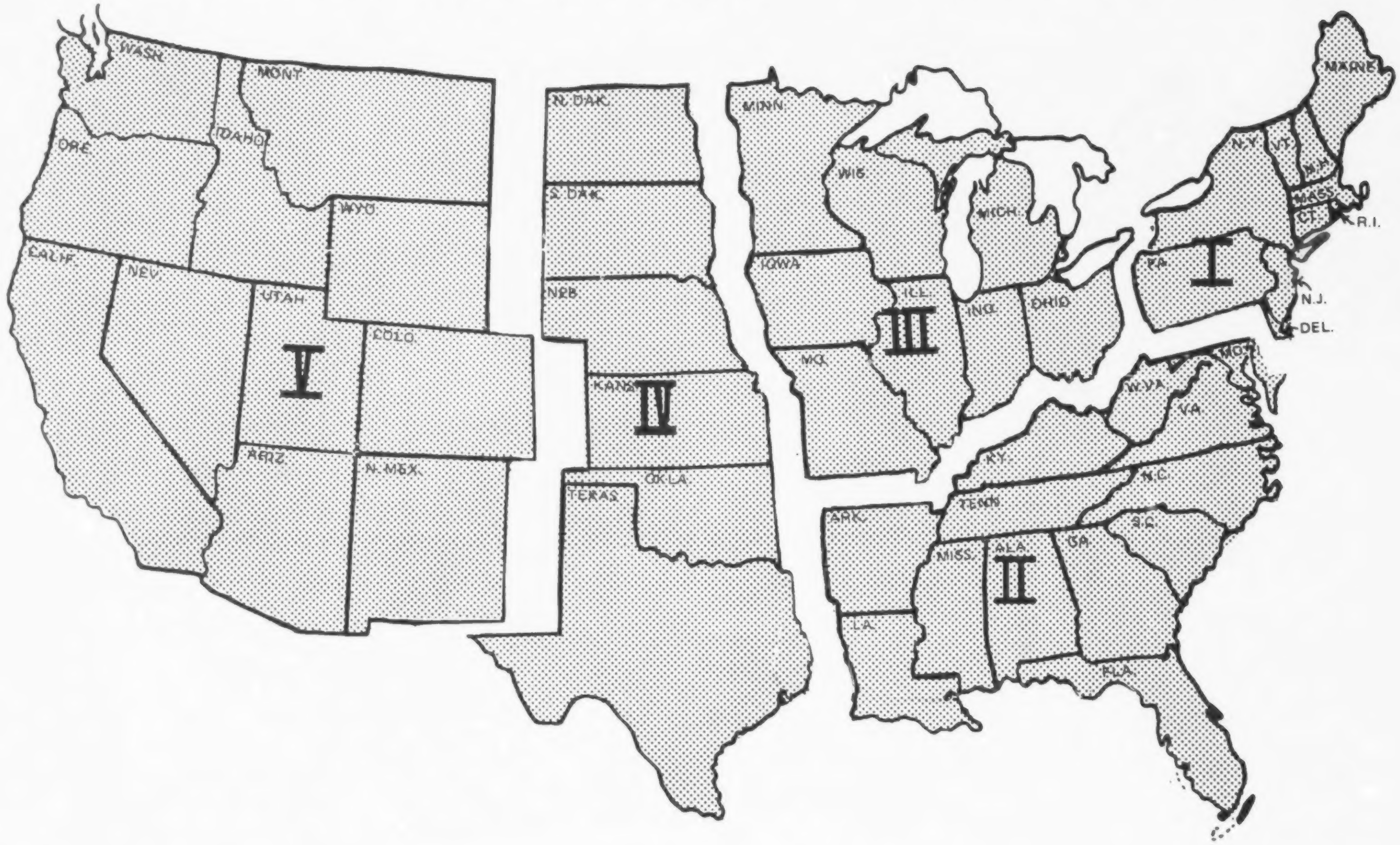
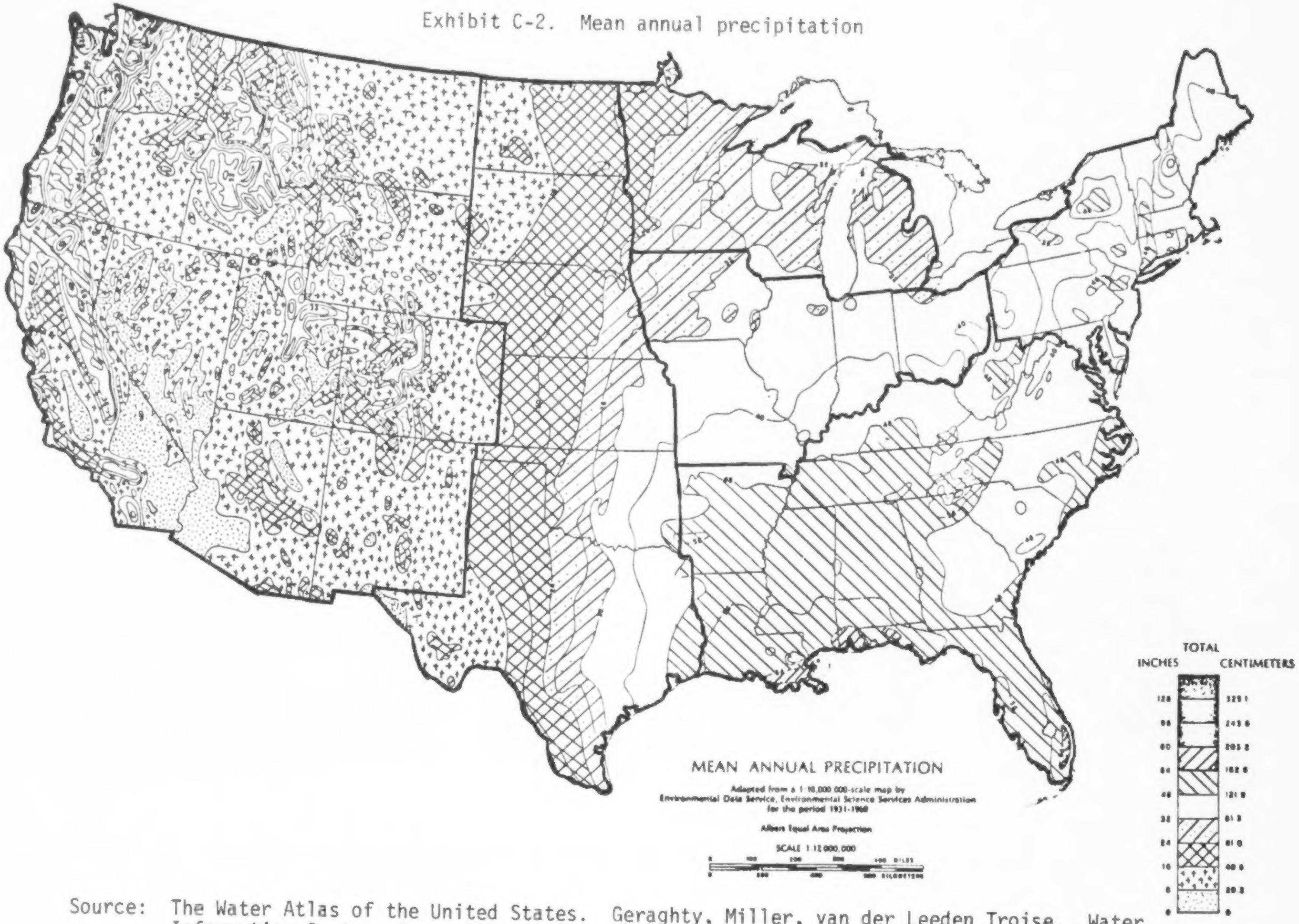

WASH.
MONT.
ORE.
IDAHO
WYO.
CALIF.
NEV.
UTAH
COLO.
V
ARIZ.
N. MEX.
N. DAK.
S. DAK.
NEB.
KANS.
IV
OKLA.
TEXAS
MINN.
WIS.
MICH.
IOWA
ILL.
IND.
OHIO
III
MO.
KY.
TENN.
ARK.
MISS.
ALA.
GA.
S.C.
N.C.
VA.
W. VA.
MD.
II
LA.
FLA.
MAINE
N.Y.
VT.
N.H.
MASS.
CT.
R.I.
PA.
I
N.J.
DEL.

Exhibit C-2. Mean annual precipitation



MEAN ANNUAL PRECIPITATION

Adapted from a 1:10,000,000-scale map by
Environmental Data Service, Environmental Science Services Administration
for the period 1931-1960

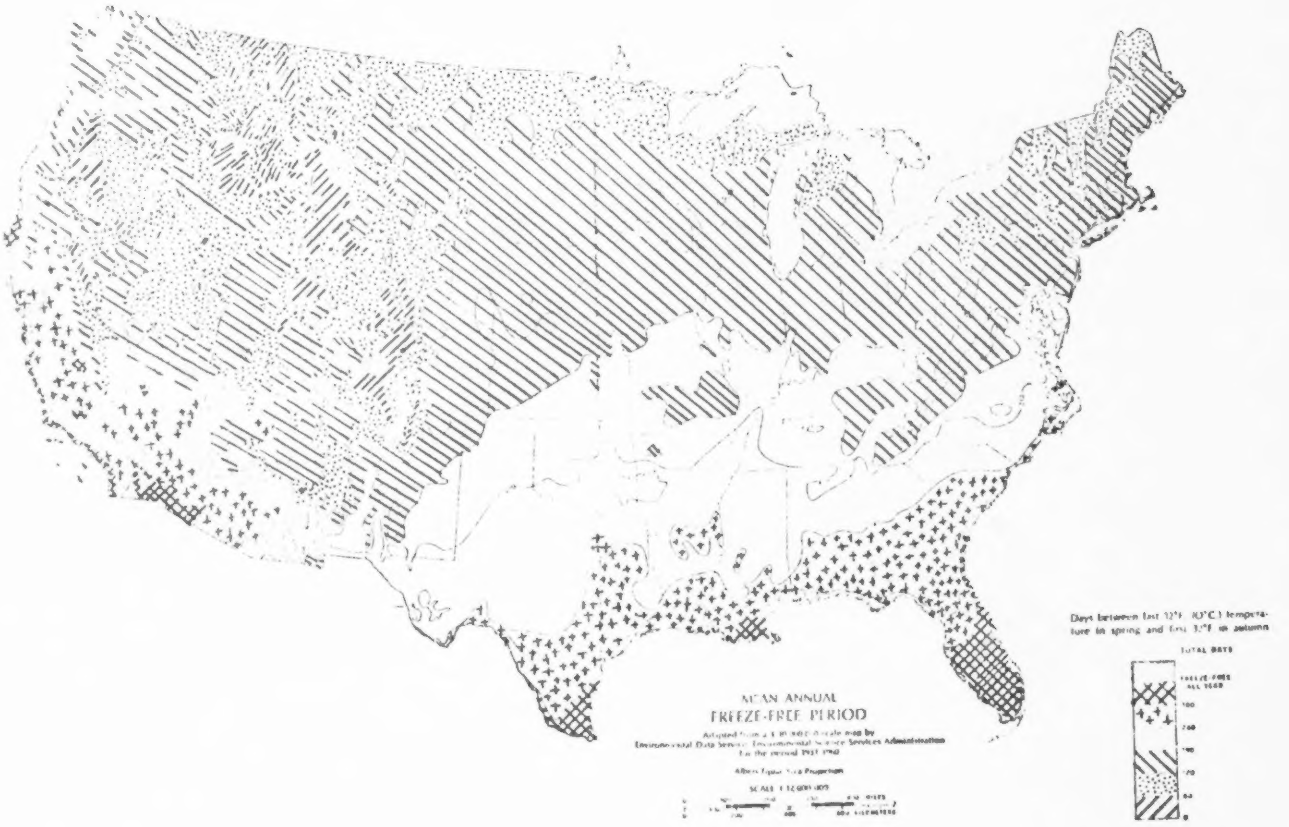
Albers Equal Area Projection

SCALE 1:12,000,000

TOTAL
INCHES
CENTIMETERS
128
96
80
64
48
32
24
16
8
0
325.1
243.8
203.2
162.6
121.9
81.3
61.0
40.6
20.3
0
0
100
200
300
400 MILES
0
200
400
600 KILOMETERS

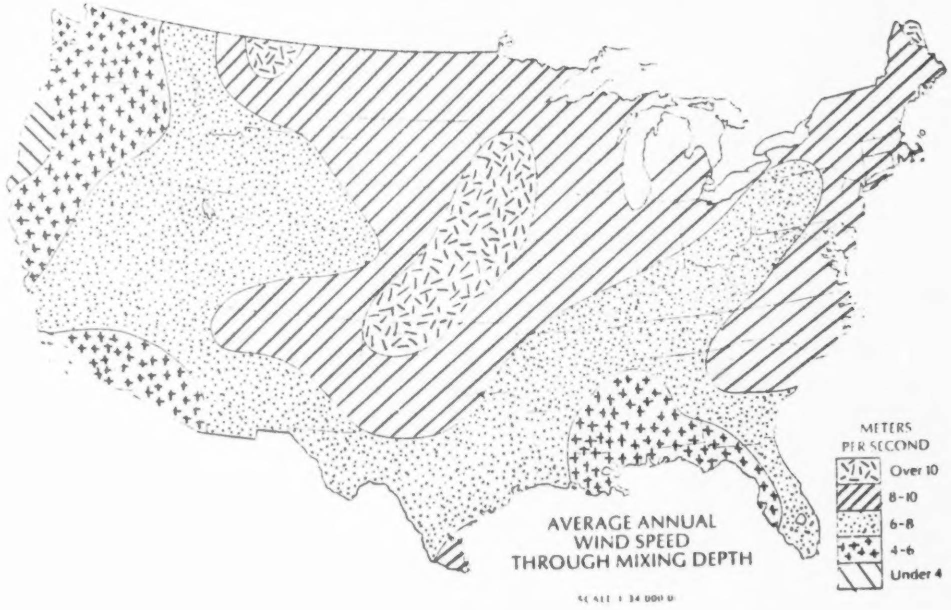
Source: The Water Atlas of the United States. Geraghty, Miller, van der Leeden Troise. Water Information Center, Inc., 1973.

Exhibit C-3. Mean annual freeze-free period


MEAN ANNUAL
FREEZE-FREE PERIOD
Adapted from a 1:10,000,000-scale map by
Environmental Data Service, Environmental Science Services Administration
for the period 1931-1960
Albers Equal Area Projection
SCALE 1:12,000,000
Days between last 32°F (0°C) temperature in spring and first 32°F in autumn
TOTAL DAYS
FREEZE-FREE ALL YEAR
300
240
180
120
60
0

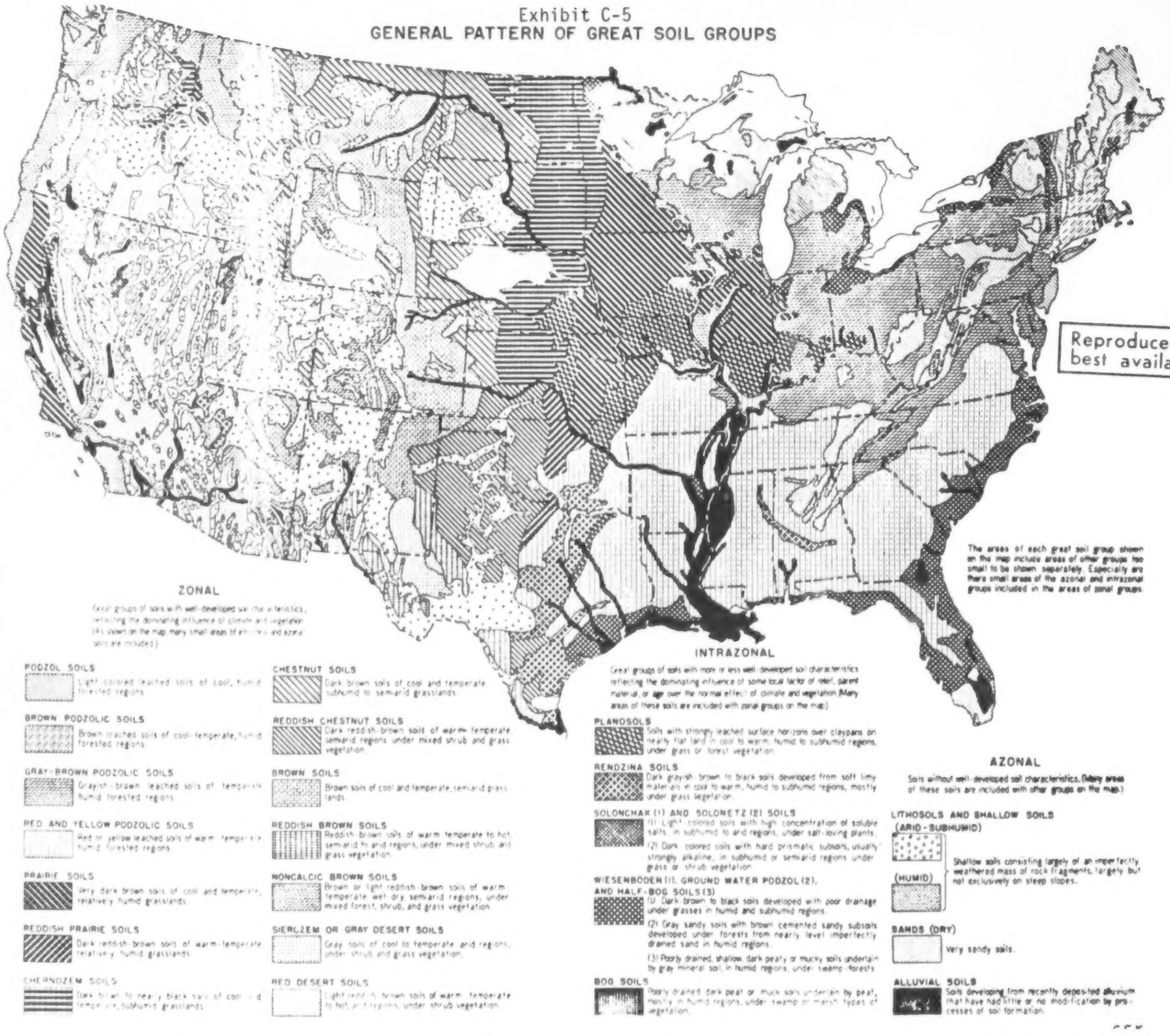
Source: The National Atlas of the United States, Geological Survey, Department of Interior, 1970.

Exhibit C-4. Mean annual wind speed through mixing depth


AVERAGE ANNUAL
WIND SPEED
THROUGH MIXING DEPTH
SCALE 1:34 000 000
METERS PER SECOND
Over 10
8-10
6-8
4-6
Under 4

Source: The National Atlas of the United States, Geological Survey, Department of Interior, 1970.

Exhibit C-5
GENERAL PATTERN OF GREAT SOIL GROUPS


ZONAL
Great groups of soils with well-developed soil characteristics, reflecting the dominating influence of climate and vegetation. (As shown on the map, many small areas of intrazonal and azonal soils are included.)
PODZOL SOILS
Light-colored leached soils of cool, humid forested regions.
BROWN PODZOLIC SOILS
Brown leached soils of cool-temperate, humid forested regions.
GRAY-BROWN PODZOLIC SOILS
Grayish-brown leached soils of temperate, humid forested regions.
RED AND YELLOW PODZOLIC SOILS
Red or yellow leached soils of warm-temperate, humid forested regions.
PRAIRIE SOILS
Very dark brown soils of cool and temperate, relatively humid grasslands.
REDDISH PRAIRIE SOILS
Dark reddish-brown soils of warm-temperate, relatively humid grasslands.
CHERNOZEM SOILS
Dark brown to nearly black soils of cool and temperate, subhumid grasslands.
CHESTNUT SOILS
Dark brown soils of cool and temperate, subhumid to semiarid grasslands.
REDDISH CHESTNUT SOILS
Dark reddish-brown soils of warm-temperate, semiarid regions under mixed shrub and grass vegetation.
BROWN SOILS
Brown soils of cool and temperate, semiarid grasslands.
REDDISH BROWN SOILS
Reddish-brown soils of warm-temperate to hot, semiarid to arid regions, under mixed shrub and grass vegetation.
NONCALCIC BROWN SOILS
Brown or light reddish-brown soils of warm-temperate, wet-dry, semiarid regions, under mixed forest, shrub, and grass vegetation.
SIERLZEM OR GRAY DESERT SOILS
Gray soils of cool to temperate, arid regions, under shrub and grass vegetation.
RED DESERT SOILS
Light reddish-brown soils of warm-temperate to hot, arid regions, under shrub vegetation.
INTRAZONAL
Great groups of soils with more or less well-developed soil characteristics reflecting the dominating influence of some local factor of relief, parent material, or age over the normal effect of climate and vegetation. (Many areas of these soils are included with zonal groups on the map.)
PLANOSOLS
Soils with strongly leached surface horizons over claypans on nearly flat land in cool to warm, humid to subhumid regions, under grass or forest vegetation.
RENDZINA SOILS
Dark grayish-brown to black soils developed from soft limy materials in cool to warm, humid to subhumid regions, mostly under grass vegetation.
SOLONCHAK (1) AND SOLONETZ (2) SOILS
(1) Light-colored soils with high concentration of soluble salts, in subhumid to arid regions, under salt-loving plants.
(2) Dark-colored soils with hard prismatic subsoils, usually strongly alkaline, in subhumid or semiarid regions under grass or shrub vegetation.
WIESENBODEN (1), GROUND WATER PODZOL (2), AND HALF-BOG SOILS (3)
(1) Dark-brown to black soils developed with poor drainage under grasses in humid and subhumid regions.
(2) Gray sandy soils with brown cemented sandy subsoils developed under forests from nearly level imperfectly drained sand in humid regions.
(3) Poorly drained, shallow, dark peaty or mucky soils underlain by gray mineral soil, in humid regions, under swamp-forests.
BOG SOILS
Poorly drained dark peat or muck soils underlain by peat, mostly in humid regions, under swamp or marsh types of vegetation.
AZONAL
Soils without well-developed soil characteristics. (Many areas of these soils are included with other groups on the map.)
LITHOSOLS AND SHALLOW SOILS
(ARID-SUBHUMID)
(HUMID)
Shallow soils consisting largely of an imperfectly weathered mass of rock fragments, largely but not exclusively on steep slopes.
SANDS (DRY)
Very sandy soils.
ALLUVIAL SOILS
Soils developing from recently deposited alluvium that have had little or no modification by processes of soil formation.
The areas of each great soil group shown on the map include areas of other groups too small to be shown separately. Especially are there small areas of the azonal and intrazonal groups included in the areas of zonal groups.

Reproduced from
best available copy.

Source: The Agricultural Regions of the United States, Ladd, Haystead and Gilbert C. Fite, University of Oklahoma Press, 1955.

Exhibit C-6. Principal rivers and drainage basins

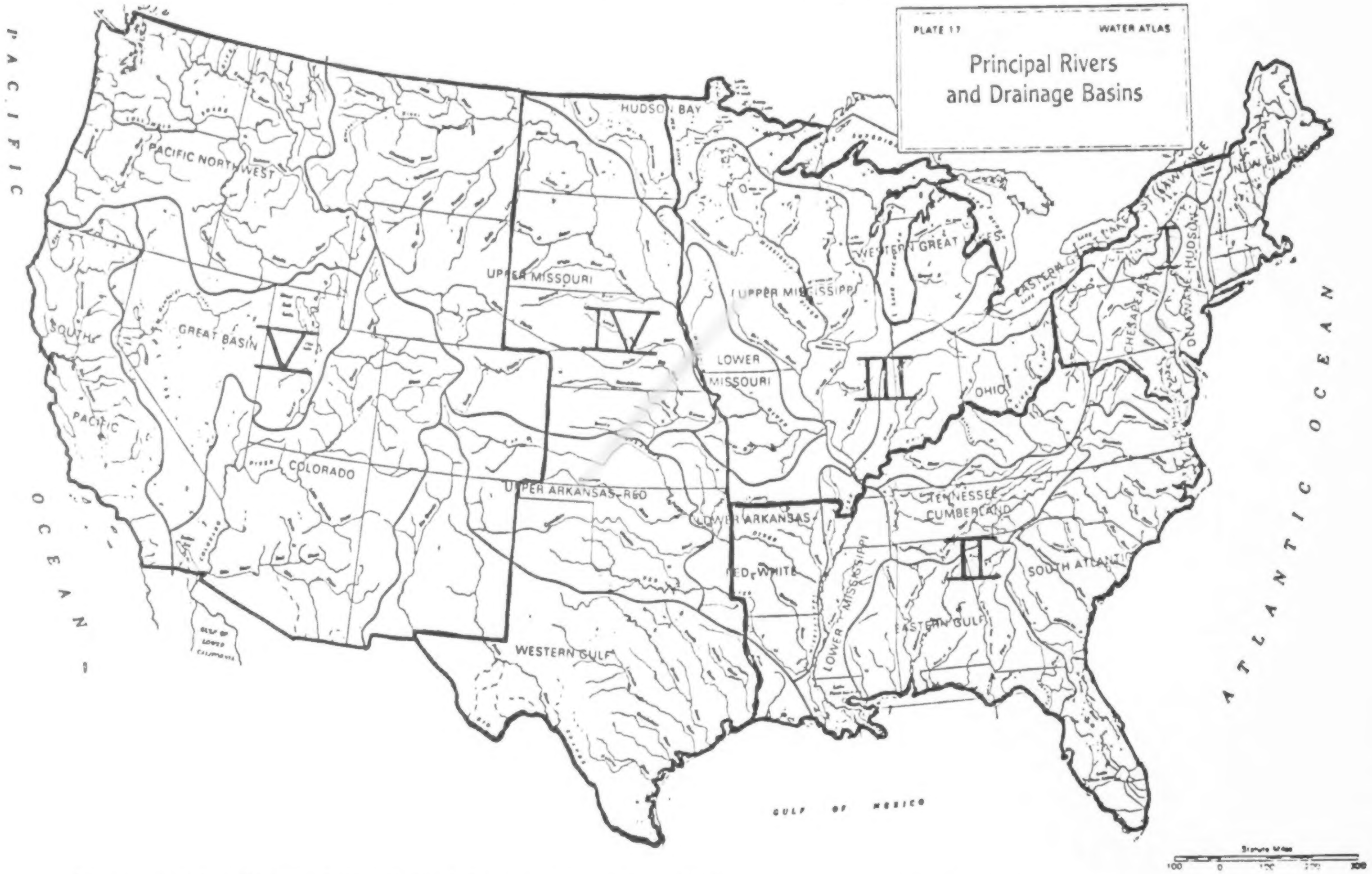
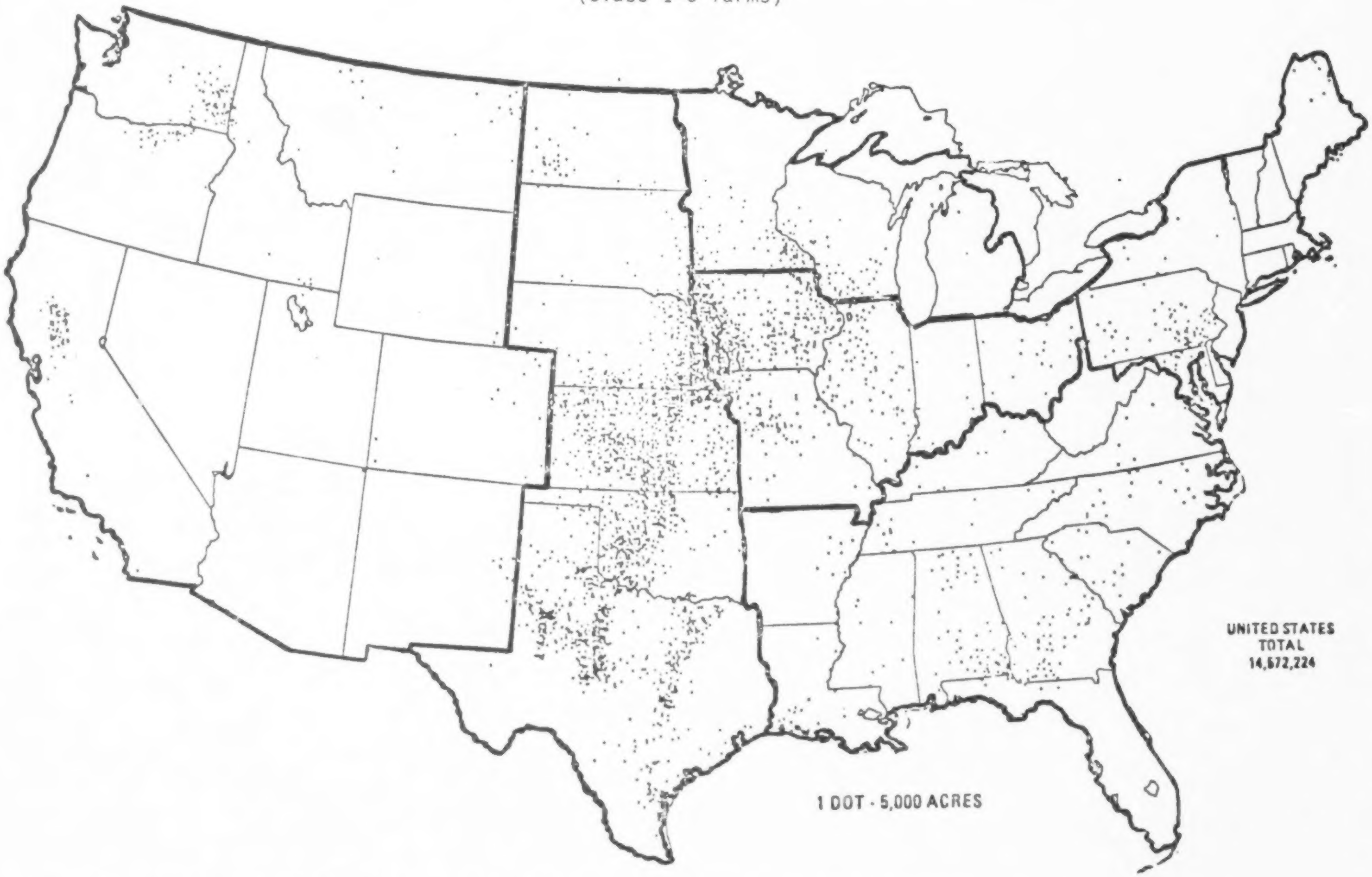


PLATE 17
WATER ATLAS
Principal Rivers and Drainage Basins
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
PACIFIC NORTHWEST
GREAT BASIN
SOUTH
PACIFIC
COLORADO
UPPER MISSOURI
HUDSON BAY
LOWER MISSOURI
UPPER MISSISSIPPI
WESTERN GREAT LAKES
EASTERN GREAT LAKES
ST LAWRENCE
NEW ENGLAND
DELAWARE-HUDSON
CHESAPEAKE
OHIO
UPPER ARKANSAS-RED
LOWER ARKANSAS
RED-WHITE
LOWER MISSISSIPPI
TENNESSEE CUMBERLAND
SOUTH ATLANTIC
EASTERN GULF
WESTERN GULF
I
II
III
IV
V
GULF OF LOWER CALIFORNIA
Statute Miles
100
0
100
200
300

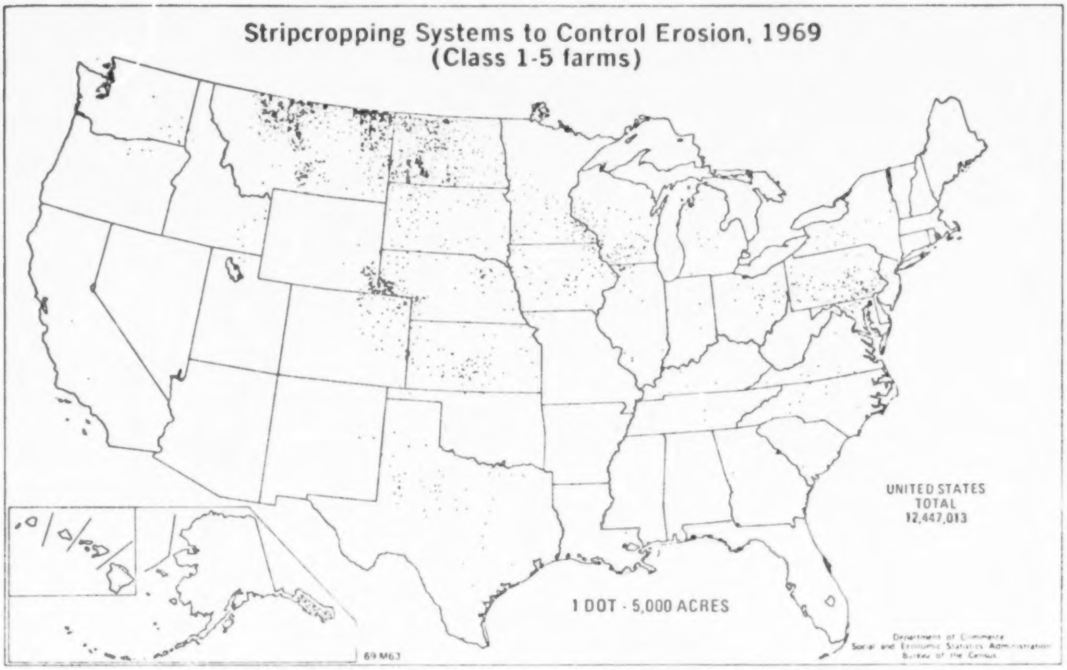
Source: Water Atlas of the United States. Geraghty, Miller, van der Leeden, Troise. Water Information Center, Inc. 1973.

Exhibit C-7. Grain or row crops farmed on the contour, 1969
(Class 1-5 farms)


UNITED STATES
TOTAL
14,672,224
1 DOT - 5,000 ACRES

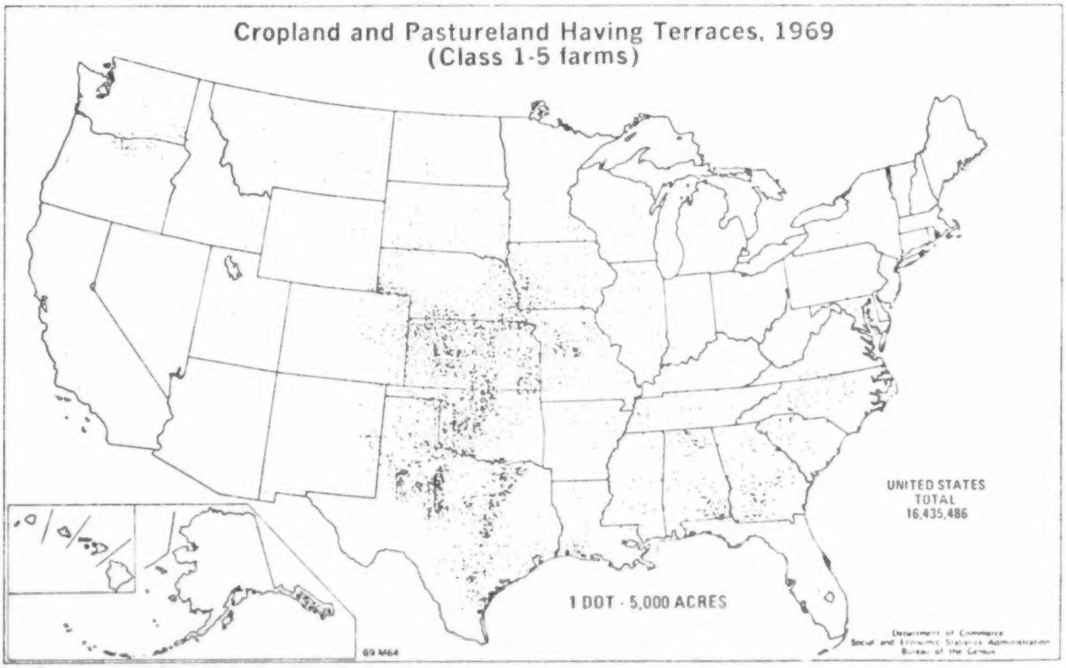
Source: Department of Commerce. Social and Economic Statistics Administration, Bureau of the Census.

Exhibit C-8. Erosion control systems, 1969



Stripcropping Systems to Control Erosion, 1969
(Class 1-5 farms)

UNITED STATES
TOTAL
12,447,013
1 DOT - 5,000 ACRES
Department of Commerce
Social and Economic Statistics Administration
Bureau of the Census
69 M63



Cropland and Pastureland Having Terraces, 1969
(Class 1-5 farms)

UNITED STATES
TOTAL
16,435,486
1 DOT - 5,000 ACRES
Department of Commerce
Social and Economic Statistics Administration
Bureau of the Census
69 M64

Source: 1969 Census of Agriculture

Exhibit C-9. Tillage method by region, 1976-1977

Region	No Tillage		Minimum Tillage		Conventional Tillage	
	1976	1977	1976	1977	1976	1977
	---------------------(000 acres)---------------------					
I-Northeastern	795	823	1,387	1,632	5,531	5,530
II-Southeastern	2,151	2,324	6,333	6,753	31,087	31,137
III-Corn Belt/ Lake States	3,745	3,939	18,961	22,087	76,129	73,736
IV-Great Plains	692	723	17,595	18,474	86,020	85,609
V-Western	146	160	7,824	9,877	25,022	23,352

Source: No-till Farmer, March, 1977.

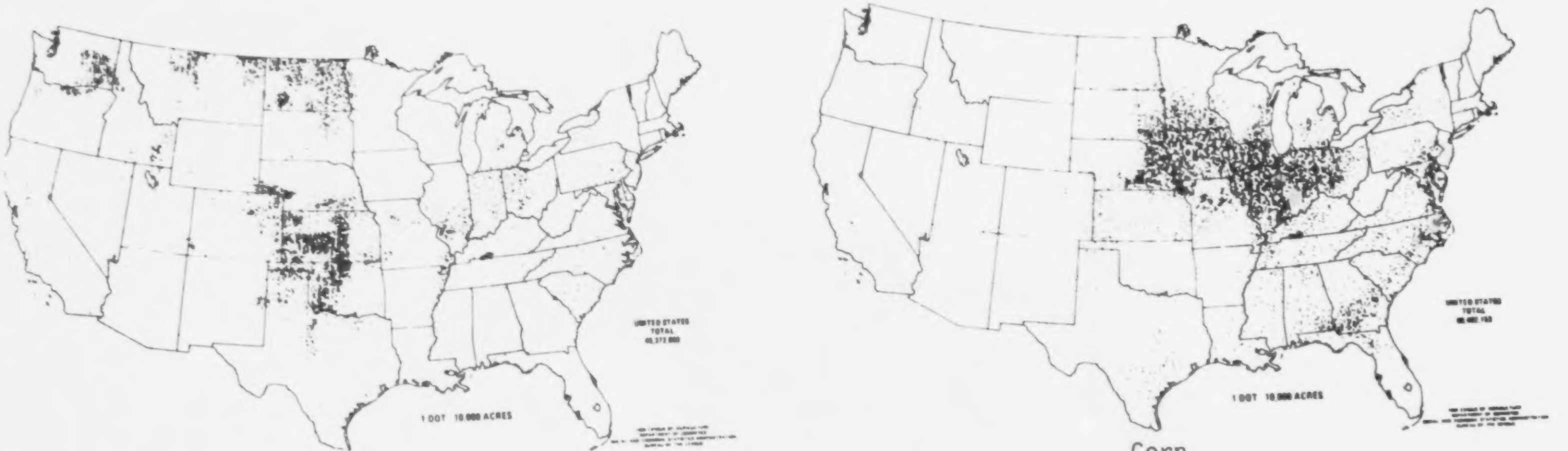
Exhibit C-10. Type of tillage by crop and region, 1977

Region	Corn			Soybeans			Grain Sorghum			Small Grains		
	No-till	Min-till	Conventional tillage	No-till	Min-till	Conventional tillage	No-till	Min-till	Conventional tillage	No-till	Min-till	Conventional tillage
	(000 acres)											
I. Northeastern	639	1,094	3,103	147 (111)	156 (54)	311 (36)	---	2	1	22	278	1,510
II. Southeastern	840	2,296	5,681	849 (649)	2,432 (861)	14,251 (4,137)	58	157	694	445	1,136	5,816
III. Cornbelt/ Lake States	2,919	9,134	37,639	875 (553)	7,264 (447)	22,477 (616)	46	279	453	20	5,126	11,122
IV. Great Plains	342	3,301	11,119	67 (37)	747 (73)	2,531 (162)	215	3,534	10,556	107	10,859	41,005
V. Western	6	405	1,395	0.3 (0.3)	1 (0.3)	3 ---	9	364	831	19	6,465	14,711

( ) denote acres of double cropped soybeans.

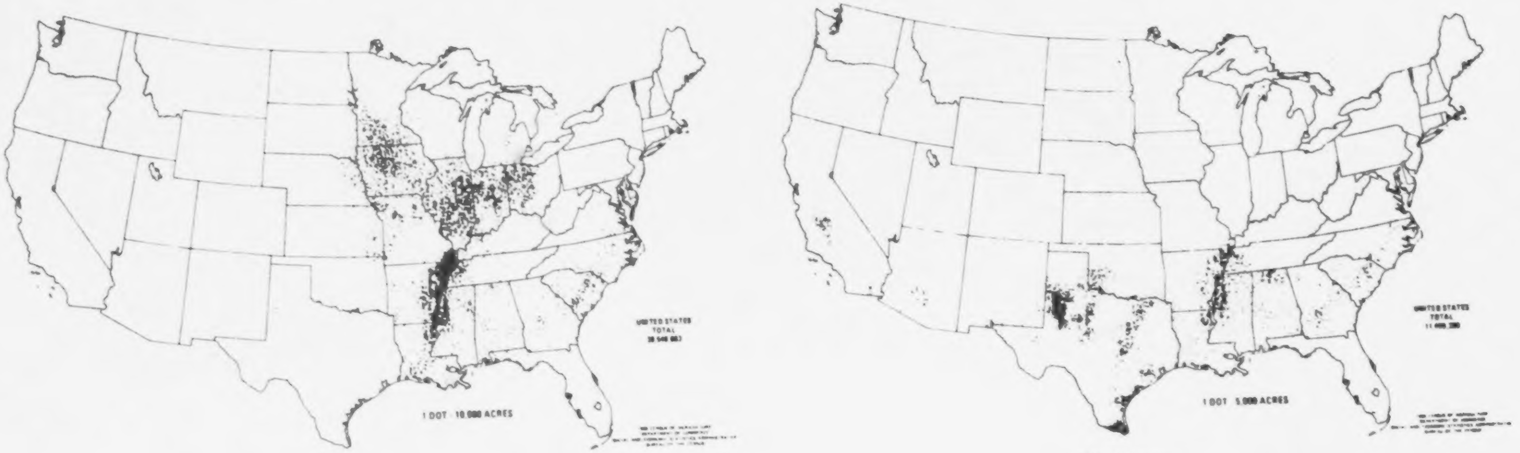
Source: No-Till Farmer, March 1977 (data rounded to nearest 1,000 acres)

Exhibit C-11. Location of cropland - corn, soybeans, cotton, wheat


UNITED STATES TOTAL
1 DOT 10,000 ACRES
UNITED STATES TOTAL
1 DOT 10,000 ACRES

Wheat

Corn

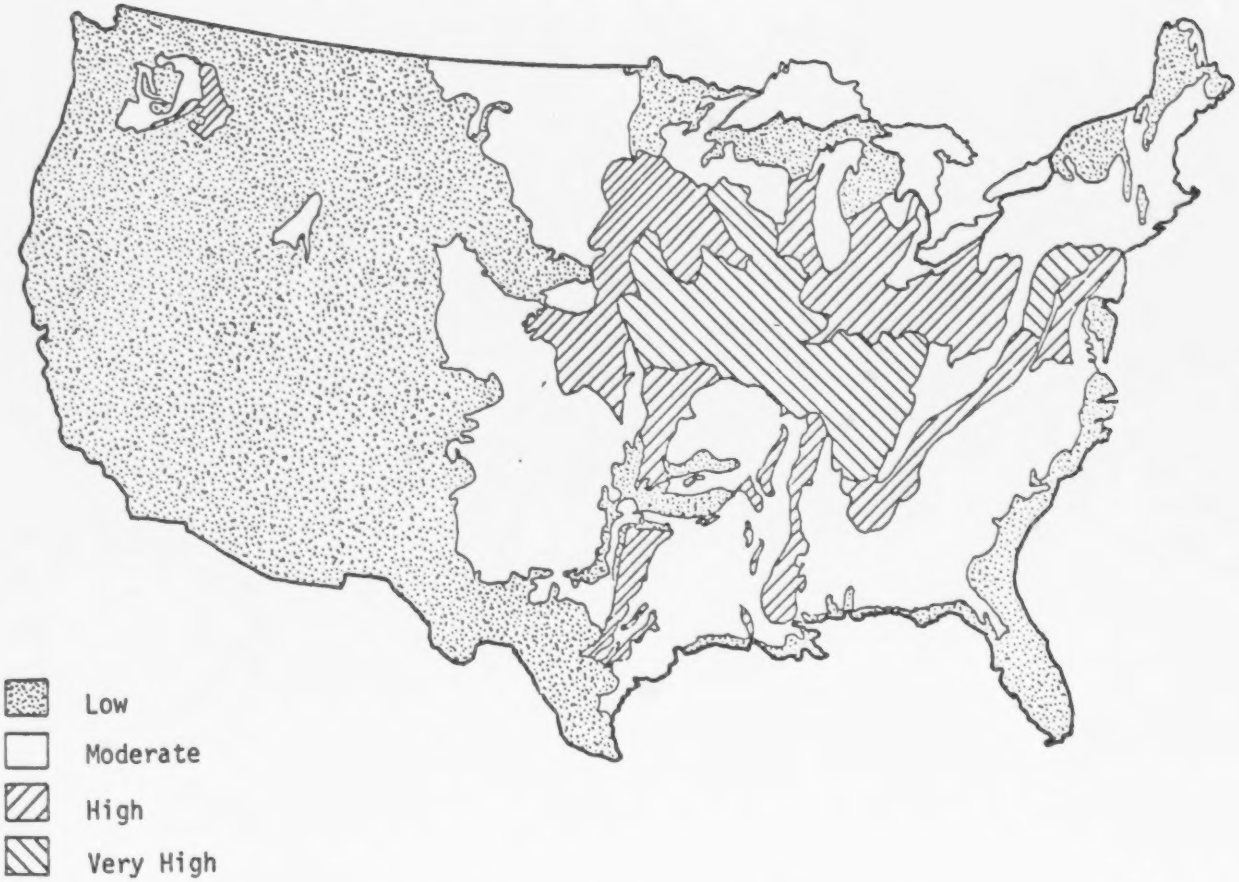

UNITED STATES TOTAL
1 DOT 10,000 ACRES
UNITED STATES TOTAL
1 DOT 5,000 ACRES

Soybeans

Cotton

Source: 1969 Census of Agriculture

Exhibit C-12. Relative potential contribution of cropland to watershed sediment yields



Source: U.S. Department of Agriculture, Environmental Protection Agency, Control of Water Pollution from Cropland, Vol. I, A manual for guideline development, November 1975.

B. Region Specific Information

Summary data 1/ are presented below for each of the study's five regions as follows:

1. Region I: Northeastern
2. Region II: Southeastern
3. Region III: Cornbelt/Lake States
4. Region IV: Great Plains
5. Region V: Western

The basic types of data, for selected (available) periods, are shown according to the following format:

a. General geography
   . Principal Rivers
   . Land Resource Regions
   . Landform
b. Climate
c. Land Use
d. Land Capability Classes
e. Potential and Current Cropland
f. Crops Grown
g. Conservation Practices
h. Moisture Control
   . Irrigation
   . Artificially Drained Land
i. Fertilizers Applied
j. Pesticides Applied

1. Region I--Northeastern

The Northeastern region is comprised of 11 states as follows:

New England States: Maine, New Hampshire, Vermont, Rhode Island, Massachusetts, Connecticut

Mid Atlantic States: New York, New Jersey, Delaware, Maryland, Pennsylvania

a. General geography

Principal Rivers and Drainage Basins: New England, Delaware-Hudson, upper Chesapeake, Eastern Great Lakes - St. Lawrence.

1/ Unless indicated otherwise, data were obtained from various U.S. Department of Agriculture publications.

Land Resource Regions: Northeastern Forage and Forest region. A portion of the Northern Atlantic Slope Truck, Fruit and Poultry Region. A portion of the East and Central General Farming and Forest Region. A portion of Lake States Fruit, Truck and Dairy Region.

Landform: Consists primarily of plains in the Coastal Region but variations include the Appalachian ridges and plateaus and plains and the Catskill Mountains.

b. Climate

Climatic region: Continental moist, humid region, vulnerable chiefly to short droughts.

Mean annual sunshine: 2,200 - 2,600 hours.

Mean annual precipitation: 40-48 inches

Mean annual freeze-free period: Range from 120-180 days with 90 days in isolated northern areas.

Average annual wind speed through mixing depth: 8-10 m/sec throughout major portion of region, with average 10 m/sec in northermost region of Maine and 6-8 m/sec in Central and Western Pennsylvania.

Mean annual pan evaporation: (81.3 cm) in Northern New England 32-48 inches (81.3 - 121.9 cm) in remainder of region.

c. Land use 1/

	1969 (1,000 acres)	1974 2/ (1,000 acres)
Farm land		
for crops	12,204	11,924
soil improvement or idle	1,980	1,082
pasture only	3,669	3,106
Total cropland	(17,853)	(16,112)
Other farmland		
open permanent pasture	2,398	
forest and woodland pasture	2,028	
forest and woodland - not pasture	5,613	
other	1,270	
Total in farms	29,162	

1/ U.S. Department of Agriculture, Agricultural Statistics, 1976.

2/ Complete 1974 data are not available.

c. (continued)

	1969 (1,000 acres)
Land not in farms	
Pasture, range	974
Woodland - not grazed	63,390
Other (including urban)	18,603
Total land area	112,129
Land in special use	
Urban area	7,282
Rural transportation	2,037
Rural parks	3,795
Wildlife refuge	1,618
National defense and industrial areas	475
State institutional and miscellaneous areas	214
Farmsteads, farm roads and lanes	386
Total	15,807

d. Land Capability Classes (1975) 1/

	%	(1,000 acres)
Class I-III	39.8	39,750
Class IV	9.9	9,908
Class V-VIII	50.3	50,334

e. Potential and current cropland - 1975 1/

Soil Class	High Potential	Medium Potential	Current
	1,000 acres		
I-III	1,658	890	14,067
IV	298	157	2,027
V-VIII	181	330	1,248
Total	2,137	1,377	17,342

1/ U.S. Department of Agriculture, Soil Conservation Service, "Potential Cropland Study," July 1976.

f. Crops Grown (1974) 1/

	(1,000 acres)
Row	4,913
Small grain	2.512
Rice	--
Sugarcane	--
Vegetables	394

Primary Crops

	(1,000 acres)
Corn	3,827
Alfalfa	1,909
Oats	896
Wheat	833
Soybeans	648
Rye	420
Vegetables	394
Barley	363
Tobacco	43

g. Conservation Practices - 1969

(approximated from Ag Census Maps)

	(1,000 acres)
On contour (Grain and Row Crops)	430
Stripcropping	249
Terraces	80

h. Moisture Control

	(1,000 acres)
Irrigation - 1969	
1.2% of cropland	
0.7% of total land in farms	
Irrigated acres	217.8
Irrigated acres - crop harvested	219.6
Irrigation by Type (1969)	
Furrows or ditches	5.0
Sprinklers	169.8
Flooding	5.9
Subirrigation	2.0
Artificially drained land	1,316

1/ Tabulated from USDA, Ag Statistics, 1976.

i. Fertilizers Applied (1974)

	(million tons)
Commercial	3.6
Natural 1/	
Milk cows	3.3
Chicken (3 months or older)	.3
Broilers	.6
Hogs and pigs	.2
Total	4.4

k. Pesticides Applied (active ingredient) 2/

	1971 (1,000 lbs)
Fungicides	9,616
Herbicides	11,880
Insecticides	7,871
Miscellaneous	238
Total	29,606

1/ Source: Manure to animal ratios (from USDA and EPA Control of Water Pollution from Cropland, Vol. 1) applied to 1974 number of animals from Agricultural Statistics.

2/ Excludes summer fallow, nursery and greenhouse crops.

2. Region II--Southeastern

The Southeastern Region is comprised of 12 states: Virginia, West Virginia, Tennessee, Kentucky, North Carolina, South Carolina, Alabama, Georgia, Florida, Mississippi, Louisiana, Arkansas.

a. General Geography:

Principal Rivers and Drainage Basins: Tennessee River, Cumberland River, Southern Ohio River, South Atlantic, Lower Mississippi River, Eastern Gulf, Red-White River and Lower Arkansas River.

Land Resource Regions: Contains all or part of the following - Atlantic and Gulf Coast Lowland Forest and Truck Crop Region; South Atlantic and Gulf Slope Cash Crop, Forest and Livestock Region; Mississippi Delta Cotton and Feed Grains Region; East and Central General Farming and Forest Region; Florida Subtropical Fruit, Truck Crop and Range Regions.

Landform: Consists of smooth flat coastal plains, open hills and low mountains in the Ozark and the Southern Appalachian Regions.

b. Climate:

Climatic region: subtropical moist; vulnerable chiefly to short droughts.

Mean annual sunshine: 2,200 - 2,400 hours in Central Appalachian Region; 2,400 - 2,800 hours in the Southern Delta States, Eastern and Western Appalachian States; 2,800 - 3,000 hours in most of Southeast area and Upper Delta States.

Mean annual precipitation: 40 - 48 inches in Appalachian area (except Tennessee) Georgia and South Carolina; 48 - 56 inches in Delta States, Western and Southern Southeast area, Tennessee.

Freeze-free period: 300 - 360 days in Southern Florida; 240 - 300 days in Southern areas up to mid-Southeast area; 180 - 240 days in Northern S.E. and Delta States, Western and Eastern Appalachian; 120 - 180 days in Central Appalachian.

Average annual wind speed: 4 - 6 m/sec. in Eastern Louisiana, Mississippi, Alabama, North and West Florida; 6 - 8 in East Florida-Georgia, Northern Alabama and Mississippi, Western Louisiana, Arkansas and Western Appalachian Region; 8-10 m/sec. in Northeastern portion of area.

Mean annual pan evaporation: 32 - 48 inches of Northern and Central Appalachian Region; 48 - 64 inches in all of remainder (South Florida and Louisiana); 64 - 80 inches in Southwest Florida and South and West Louisiana.

c. Land Use [1]

	1969 (1,000 acres)	1974[2] (1,000 acres)
Farm land		
for crops	42,230	41,050
soil improvement or idle	9,636	5,357
pasture only	24,746	23,643
Total cropland	(76,612)	(70,050)
Other farmland		
open permanent pasture	21,761	
forest and pasture	19,311	
woodland - not pasture	28,350	
other	4,721	
Total in farms	150,755	
Land not in farms		
Pasture, range	27,962	
Woodland - not grazed	130,635	
Other	30,416	
Total land area	339,768	
Land in special use		
Urban area	8,286	
Rural transportation areas	5,609	
Rural parks	2,631	
Wildlife refuge	2,523	
National defense and industrial areas	2,836	
State institutional and miscellaneous users	825	
Farmsteads, farm roads and lanes	1,959	
Total	24,669	

d. Land Capability Classes (1975) [3]

	%	(1,000 acres)
Class I-III	46.9	143,040
Class IV	16.2	49,423
Class V-VIII	36.9	112,720

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[1] U.S. Department of Agriculture, Agricultural Statistics, 1976.

[2] Complete 1974 data were not available.

[3] U.S. Department of Agriculture, Soil Conservation Service, "Potential Cropland Study," July 1976.

e. Potential and current cropland - 1975 1/

Soil Class	High Potential	Medium Potential	Current
	------------------1,000 acres-------------------		
I-III	24,058	9,291	49,523
IV	2,510	3,611	4,727
V-VIII	656	916	2,817
Total	27,224	13,818	57,067

f. Crops Grown (1974)

	(1,000 acres)
Row	39,817
Grain	5,293
Rice	1,505
Sugarcane	604
Primary Crops	
Soybeans	17,202
Corn	8,730
Cotton	5,680
Wheat	2,863
Rice	1,505
Oats	1,169
Peanuts	1,082
Rye	925
Tobacco	889
Sorghum	701
Sugarcane	604
Vegetables	556
Barley	336

g. Conservation Practices (1969) (approximated from Ag Census Maps)

	(1,000 acres)
On contour (Grain and Row Crops)	2,186
Stripcropping	100
Terraces	810

h. Moisture Control

Irrigation
2.1% of total land in farms
4.4% of cropland

1/ U.S. Department of Agriculture, Soil Conservation Service, "Potential Cropland Study," July 1976.

h. (Continued)

	(1,000 acres)
Irrigated acres	3,411.0
Irrigated acres - crops harvested	3,038.9
Irrigation by Type (1969 Census)	
Furrows or ditches	964.0
Sprinklers	744.3
Flooding	1,492.9
Subirrigation	244.6
Artificially drained land	12,050

i. Fertilizer (1974)

	(1,000 tons)
Commercial	13,373
Natural 1/	
Manure (dry weight)	
Cattle fattened	
Milk cows	2,564
Hogs and pigs	1,749
Chickens (3 months or older)	790
Broilers	2.790
Total	7,893

j. Pesticides (active ingredients) 2/

	1971 (1,000 lbs)
Fungicide	68,881
Herbicide	51,024
Insecticide	104,633
Miscellaneous	17,531
Total	242,069

1/ Source: Manure to animal ratios (from USDA and EPA Control of Water Pollution from Cropland, Vol. 1) applied to 1974 number of animals from Agricultural Statistics.

2/ Excludes summer fallow, nursery and greenhouse crops.

3. Region III - Cornbelt/Lake States

The Cornbelt/Lake States region is comprised of eight states: Missouri, Iowa, Illinois, Indiana, Ohio, Wisconsin, Minnesota, and Michigan.

a. General Geography:

Principal Rivers and Drainage Basins: Lower Missouri, Northern Ohio, Upper Mississippi, Western Great Lakes.

Land Resource Regions: Central Feed Grains and Livestock Region. A portion of the East and Central General Farming and Forest Region in southern Missouri, extreme southern Indiana and southeast Ohio. Northern Lake States, Forest and Forage Region.

Landform: Primarily, smooth plains with high hills in Ozarks, open hills in southeastern Ohio and swamps and lakes in the north.

b. Climate:

Climatic region: Continental moist; humid region, vulnerable chiefly to short droughts.

Mean annual sunshine: 2,200 hours in north, increasing to 2,400 to south and east and increasing to 2,800 in western portion.

Mean annual precipitation: 32 inches in north increasing to 48 inches in south.

Mean annual freeze-free period: Varies from 60 - 120 days in the Lake States, 120 days in southern Illinois and Missouri, to 150 - 180 days throughout most of the remainder of the region.

Average annual wind speed through mixing depth: 8 meters per second in eastern portion increasing to 10 meters per second in the western portion.

Mean annual pan evaporation: 16 inches in northern Lake States, 32 inches in the east increasing to 48 inches in Missouri and the western half of Iowa.

c. Land Use 1/

	1969 (1,000 acres)	1974 2/ (1,000 acres)
Farm Land		
for crops	102,225	110,836
soil improvement or idle	21,897	6,358
pasture only	22,179	19,780
Total cropland	(146,301)	(136,974)
Other farmland		
open permanent pasture	12,978	
forest and pasture	12,393	
woodland - not pasture	10,489	
other	7,281	
Total in farms	189,442	
Land - not in farms		
Pasture, range	11,462	
Woodland - not grazed	56,374	
Other (includes urban)	29,651	
Total Land Area	286,929	
Land in special use		
Urban area	8,634	
Rural transportation	6,735	
Rural parks	2,125	
Wildlife refuge	2,234	
National defense and industrial areas	489	
State institutional and miscellaneous uses	185	
Farmsteads, farm roads and lanes	3,075	
Total	23,477	

d. Land Capability Classes 3/ (1975)

	%	(1,000 acres)
Class I-III	67.8	175,700
Class IV	13.9	36,021
Class V-VIII	18.3	47,589

1/ U.S. Department of Agriculture, Agricultural Statistics, 1976.

2/ Complete 1974 data were not available.

3/ U.S. Department of Agriculture, Soil Conservation Service, "Potential Cropland Study," July 1976.

e. Potential and current cropland - 1975 1/

Soil Class	High Potential	Medium Potential	Current
	1,000 acres		
I-III	13,806	3,230	119,286
IV	1,640	650	8,485
V-VIII	93	1,454	3,152
Total	15,549	5,334	130,923

f. Crops Grown

	1969 (1,000 acres)
Row	84,247
Grain	19,092
Rice	15
Primary Crops	
Corn	49,060
Soybeans	32,320
Wheat	10,219
Alfalfa	10,025
Oats	7,385
Barley	907
Vegetable	903
Sorghum	705
Rye	571
Cotton	371
Sugarbeets	305
Flaxseed	280
Tobacco	30
Rice	15

g. Conservation Practices - 1969

(approximated from Ag Census maps)	(1,000 acres)
On contour (Grain and Row Crops)	4,728
Stripcropping	373
Terraces	1,972

h. Moisture Control

Irrigation
0.3% of cropland
0.2% of land in farms

1/ U.S. Department of Agriculture, Soil Conservation Service, "Potential Cropland Study," July 1976.

h. (Continued)

	1969 (1,000 acres)
Irrigation - by Type (1969 Census)	
Furrows or ditches	76.7
Sprinklers	309.3
Flooding	75.4
Subirrigation	9.4
Artificially drained land	36,153

i. Fertilizer (1974)

	(1,000 tons)
Commercial	16,030
Natural 1/	
Manure (dry weight)	
Cattle (feedlot	3,573
Milk cows	7,068
Hogs and pigs	7,173
Chicken (3 months and older)	629
Total	18,443

j. Pesticides (active ingredient) 2/

	1971 (1,000 lbs)
Fungicides	7,766
Herbicides	118,323
Insecticides	25,173
Miscellaneous	501
Total	151,763

1/ Source: Manure to animal ratios (from USDA and EPA Control of Water Pollution from Cropland, Vol. 1) applied to 1974 number of animals from Agricultural Statistics.

2/ Excludes summer fallow, nursery and greenhouse crops.

4. Region IV--Great Plains

The Great Plains regions is comprised of six states: Kansas, Nebraska, North Dakota, South Dakota, Texas, and Oklahoma

a. General Geography:

Principal Rivers and Drainage Basins: Hudson Bay, Upper Missouri, Upper Arkansas - Red, Western Gulf.

Land Resource Regions: The eastern portions of Northern Great Plains Spring Wheat Region; Western Great Plains Range and Irrigated Region. Essentially all of: Central Great Plains Winter Wheat and Range Region; Southwestern Plateau and Plains Range and Cotton Region; Southwestern Prairies Cotton and Forage Region; The Western portions of Atlantic and Gulf Lowland Forest and Truck Crop Region; South Atlantic and Gulf Slope Cash Crop; Forest and Livestock Region.

Landforms: Smooth to irregular plains interspersed with open hills, and with mountains in South Dakota.

b. Climate:

Climatic region: Continental moist in eastern portion and Continental Steppe in Western portion.

Mean annual sunshine: 2,800 hours on Texas Gulf Coast, decreasing to 2,600 inland, increasing again to 2,800 in central Texas, increasing to 3,000 hours throughout most of region, decreasing to 2,800 in South Dakota and to 2,600 in North Dakota.

Mean annual precipitation: Decreases from east to west - 40 inches in eastern Texas, Oklahoma and Kansas, decreases rather uniformly to 20 inches in central portion to 16 at western edge of region with further decrease in southwest Texas and western North and South Dakota.

Mean annual freeze-free period: Range; 90 days in northernmost North Dakota to over 300 in south Texas.

Average annual wind speed through mixing depth: Changes from 8 - 10 in south Texas, decreasing to 6 - 8 m/sec in central Texas increasing to 8 - 10 m/sec throughout remainder of region except for eastern Nebraska and the major portion of Kansas where speed averages over 10 m/sec.

Mean annual pan evaporation: Tremendous variation within region; 112 inches in southwest Texas decreasing to 96 inches further north, 80 inches in central Texas, western Oklahoma and Kansas, 64 inches in eastern Texas, Oklahoma, Kansas and central and western Nebraska, 48 inches in northern Nebraska, most of South Dakota and western North Dakota, with 32 inches in remainder of region.

c. Land Use 1/

	1969 (1,000 acres)	1974 2/ (1,000 acres)
Farm Land		
for crops	122,220	98,246
soil improvement or idle	12,954	25,352
pasture only	28,106	28,140
Total cropland	(163,280)	(151,738)
Other farmland		
open permanent pasture	180,200	
forest and pasture	11,271	
woodland - not pasture	2,196	
other	5,554	
Total in farms	362,501	
Land - not in farms		
Pasture, range	21,517	
Woodland - not grazed	6,591	
Other	15,420	
Total Land Area	406,029	
Land in special use		
Urban area	4,121	
Rural transportation	5,800	
Rural areas	1,659	
Wildlife refuge	1,408	
National defense and industrial areas	1,153	
State institutional and miscellaneous areas	368	
Farmsteads, farm roads and lanes	1,902	
Total	16,411	

d. Land Capability Classes (1975) 3/

	%	(1,000 acres)
Class I-III	51.7	198,360
Class IV	11.0	42,403
Class V-VIII	37.3	143,060

1/ U.S. Department of Agriculture, Agricultural Statistics, 1976.

2/ Complete 1974 data were not available.

3/ U.S. Department of Agriculture, Soil Conservation Service, "Potential Cropland Study," July 1976.

e. Potential and current cropland - 1975 1/

Soil Class	High Potential	Medium Potential	Current
	----------	1,000 acres	----------
I-III	18,191	4,247	113,712
IV	2,507	851	12,408
V-VIII	1,176	1,636	5,705
Total	21,874	6,734	131,825

f. Crops Grown

	1974 (1,000 acres)
Row	44,089
Grain	52,680
Rice	565
Sugarcane	29
Primary Crops	
Wheat	41,355
Sorghum	15,085
Corn	14,417
Spring wheat	12,630
Alfalfa	7,630
Oats	7,220
Cotton	5,770
Soybeans	3,337
Barley	3,000
Flaxseed	1,456
Rye	1,105
Rice	565
Peanuts	430
Sugar beets	284
Vegetables	194
Sugarcane	29

g. Conservation Practices - 1969

(approximated from Ag Census Maps)	(1,000 acres)
On contour	6,500
Stripcropping	6,124
Terraces	13,148

1/ U.S. Department of Agriculture, Soil Conservation Service, "Potential Cropland Study," July 1976.

h. Moisture Control

	(1,000 acres)
Irrigation (1969 Census)	
7.3% of cropland	
3.3% of total farmland	
Irrigated acres	11,910.6
Irrigated acres - crops harvested	11,034.2
Irrigation - by Type	
Furrows or ditches	8,116.8
Sprinklers	2,177.0
Flooding	1,618.7
Subirrigation	47.0
Artificially drained land	5,312

i. Fertilizer (1974)

	(1,000 tons)
Commercial	7,584
Natural 1/	
Manure (dry weight)	
Cattle (feedlot) 30%	6,008
Milk cows	1,600
Hogs and pigs	1,614
Chickens (3 months and older)	176
Broilers, etc.	285
Total	9,683

j. Pesticides (active ingredients) 2/

	1971 (1,000 lbs)
Fungicides	8,289
Herbicides	75,746
Insecticides	26,055
Miscellaneous	8,815
Total	118,905

1/ Source: Manure to animal ratios (from USDA and EPA Control of Water Pollution from Cropland, Vol. 1) applied to 1974 number of animals from Agricultural Statistics.

2/ Excludes summer fallow, nursery and greenhouse crops.

5. Region V--Western

The Western Region is comprised of eleven states: Nevada, Idaho, New Mexico, Arizona, Utah, Montana, Colorado, Wyoming, Washington, Oregon, and California.

a. General Geography:

Principal Rivers and Drainage Basins: Pacific Northwest, Great Basin, South Pacific, Colorado and the western portions of the Upper Missouri, Upper Arkansas - Red, and Western Gulf.

Land Resource Regions: Northwestern Forest, Forage and Specialty Crop Region; Northwestern Wheat and Range Region; California Subtropical Fruit, Truck and Specialty Crop Region; Western Range and Irrigated Region; Rocky Mountain Range and Forest Region and the western portion of Northern Great Spring Wheat Region; Western Great Plains Range and Irrigated Region.

Landform: The sharpest contrast of any region. Flat plains in the Sacramento and San Joaquin River Valley to plains with low mountains and high rugged Rocky Mountains.

b. Climate:

Climatic region: Marine temperate, subtropical dry, desert, continental steppe.

Mean annual sunshine: 4,000 hours in the southeastern tip of California and the southwestern decreasing to 1,800 hours in northwest Washington.

Mean annual precipitation: Varies from 0 - 8 inches in desert areas to 128 inches in coastal areas of Washington. Major portion of region 16 inches or less.

Mean annual freeze-free period: Varies from over 300 days to less than 90 days in mountains and northern areas.

Average annual wind speed through mixing depth: Under 4 m/sec on coast of southern Oregon and northern California, increasing up to 6 m/sec further inland, increasing to 8 m/sec throughout central portion of region, increasing up to 10 m/sec in eastern central and northeast portion of region.

Mean annual pan evaporation: Varies from a high of 144 inches in desert region to 16 inches on Washington Coast.

c. Land Use 1/

	1969 (1,000 acres)	1974 2/ (1,000 acres)
Farm Land		
for crops	54,075	40,775
soil improvement and idle	4,441	15,978
pasture only	9,517	8,028
Total Cropland	(68,033)	(63,781)
Other farmland		
open permanent pasture	232,692	
forest and pasture	17,408	
woodland - not pasture	2,920	
other	8,826	
Total in farms	329,879	
Land not in farms		
Pasture and range	225,565	
Woodland - not grazed	99,904	
Other	100,865	
Total land area	756,213	
Land in special use		
Urban area	6,067	
Rural transportation	5,524	
Rural parks	31,062	
Wildlife refuge	4,334	
National defense and industrial areas	17,935	
State institutional and miscellaneous uses	300	
Farmsteads, farm roads and lanes	1,073	
Total	66,295	

d. Land Capability Classes (1975) 3/

	%	(1,000 acres)
Class I-III	20.2	77,283
Class IV	10.8	41,358
Class V-VIII	69.0	264,564

1/ U.S. Department of Agriculture, Agricultural Statistics, 1976.

2/ Complete 1974 data were not available.

3/ U.S. Department of Agriculture, Soil Conservation Service, "Potential Cropland Study," July 1976.

e. Potential and current cropland - 1975 1/

Soil Class	High Potential	Medium Potential	Current
	1,000 acres		
I-III	7,652	2,039	47,112
IV	1,421	1,765	12,110
V-VIII	2,288	1,528	3,337
Total	11,361	5,332	62,559

f. Crops Grown (1974)

	(1,000 acres)
Row	10,981
Grain	21,938
Rice	470
Sugarcane	101

Primary Crops

Wheat	16,084
Alfalfa	6,569
Barley	4,388
Spring wheat	3,527
Cotton	1,795
Corn	1,753
Oats	1,297
Sorghum	1,185
Vegetables	1,271
Sugar beets	662
Rice	470
Rye	169
Sugarcane	101
Flaxseed	23
Peanuts	8

g. Conservation Practices - 1969
(approximated from Ag Census Maps)

	(1,000 acres)
On contour	728
Stripcropping	5,601
Terraces	425

h. Moisture Control

Irrigation - 1969 Census
32.4% of cropland
6.7% of total land in farms

1/ U.S. Department of Agriculture, Soil Conservation Service, "Potential Cropland Study," July 1976.

h. (Continued)

	(1,000 acres)
Irrigated acres	22,042.1
Irrigated acres - crop harvested	18,167.0
Irrigation - by Type	
Furrows or ditches	9,820.9
Sprinklers	3,731.7
Flooding	8,665.2
Subirrigation	290.0
Artificially drained land	4,678

i. Fertilizer (1974)

	1974 (million tons)
Commercial	7.4
Natural 1/	
Manure (dry weight)	
Cattle (feedlot)	3.42
Milk cows	2.28
Hogs and pigs	.23
Chickens (3 months or older)	.40
Broilers	.19
Total	6.52

j. Pesticides (active ingredient) 2/

	1971 (1,000 lbs)
Fungicides	60,096
Herbicides	111,440
Insecticides	51,245
Miscellaneous	19,187
Total	238,968

1/ Source: Manure to animal ratios (from USDA and EPA Control of Water Pollution from Cropland, Vol. 1) applied to 1974 number of animals from Agricultural Statistics.

2/ Excludes summer fallow, nursery and greenhouse crops.